THE FLORAL ANATOMY OF KAEMPFERIA ROSEA
Schweinf. ex Benth. WITH SPECIAL REFERENCE
TO THE GLANDS IN ZINGIBERACEAE

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ABSTRACT

The floral anatomy of Kaempferia rosea is studied in detail. Anatomic observations demonstrate fusion of vascular strands of different floral whorls. The inferior ovary is considered to be a result of extreme degrees of adnation.

The developmental aspects of the glands and their vascular supply in the present plant are discussed in comparison with those of other zingiberaceous species. It is regarded that in this family the septal nectaries are replaced by vascularized emergences of carpellary tissue which exhibit a progressive series in their elevation from a position within the septa to one truly epigynous. The Costae are thought to be the simplest in this respect.

INTRODUCTION

ALTHOUGH studies in the floral anatomy of the Zingiberaceae have been extensive in recent years, still certain aspects of floral morphology are in need of further clarification. In an earlier communication (Pai, 1965), the present writer presented anatomical evidence in support of the classical concept of the labellum. The present investigation adduces evidence in regard to the development of the nectaries in Zingiberaceae and some features of their evolutionary modifications.

MATERIAL AND METHODS

The flowering material was collected from the Victoria Gardens, Bombay, and fixed in F.A.A. Serial transections (12–14μ in thickness) were stained in crystal violet using erythrosin as counterstain.

Further anatomical evidence is adduced to indicate that the labellum is a double structure.
DESCRIPTION

The pedicel contains two rings of vascular bundles with 9–11 in the outer and six in the inner. Three of the bundles of the inner ring are larger and alternate with smaller ones (Fig. 1). The latter move outwards and then upwards in the ovary wall opposite the loculi and represent the fused carpellary dorsals-cum-median bundles of the sepals. The three larger bundles laterally extend and unite to form a siphonostelic structure. Just beneath the level of the loculi, it differentiates into the placental bundles and three prominent strands (Fig. 2). Radially outside to each of these is present a bundle of the outer ring with which they fuse to form the composite parietal bundles that extend opposite the septa of the ovary (Fig. 3). The remaining bundles of the outer ring—six in number at this level—traverse the ovary wall. The latter thus contains 12 vascular bundles.

The ovary is trilocular with the placentation axile. The ovules are borne in two rows in each loculus, and are supplied by traces from the placental strands. The latter are not exhausted in bearing traces to the ovules as usually happens in the studied species of the tribe Hedychieae to which the present plant belongs, but get arranged in three groups that extend upwards (Figs. 4–5). Two of the groups are prominent and antero-lateral while the posterior one is comparatively attenuated (Figs. 5–6). The latter ends at the top of the ovary. The ovarian loculi are continued upwards in the form of three cavities (Fig. 6) which merge to form a single V-shaped canal at the level of the plexus (Fig. 7).

At the top of the ovary, the DMS cords split into the constituent strands (Fig. 6). The carpellary dorsals are distinctly reduced bundles and end at the level of the plexus. Each of the parietal bundles divides into three tangentially placed bundles (Figs. 6–7), which along with the lateral strands of the ovary wall bear lateral branches to form a vascular anastomosis (Fig. 7). From this plexus are derived the three stylar traces (Fig. 7), that flank the V-shaped canal. The lateral strands send out lateral traces of the sepals (Fig. 7). Each of the sepals receives three bundles.

A little above the level of the plexus, the glands appear lodged in cavities (Fig. 8). The calyx and the style separate out later. Within the glands, the vascular tissue (the placental bundles) increases in size and towards the middle of their length is in the form of a plate extending in an antero-posterior direction (Fig. 9). Upwards, the vascular tissue is steadily reduced to a single strand. The glands lie freely within the floral tube (Fig. 9).
Floral Anatomy of Kaempferia rosea Schweinf. ex Benth.

The floral tube represents the fused corolla and the androecial members. At its base, it contains 20-22 strands (Fig. 9). Of these, three groups of strands which represent the upward continuations of the parietal bundles above the level of the plexus (Fig. 8) stand out conspicuously. The laterals

Figs. 1-9. Kaempferia rosea—Serial transections of the flower from below upward, up to the base of the floral tube.
of these groups are tangentially oriented (Figs. 8–9). The medians of the antero-laterals represent the median bundles of the lateral petals. The laterals of the group are continued into the labellum. The median of the posterior set divides into an outer median bundle of the posterior petal and an inner strand which along with the laterals of the group represent the main vascular supply of the functional stamen. Two prominent postero-lateral bundles of the floral tube which are radially opposite the MS traces (Figs. 8–9) represent the median bundles of the lateral staminodes of the outer androecial whorl. The vascular supply of the anterior member of the androecium is not represented in the flower. The remaining bundles of the floral tube constitute the fused traces of the corolla and the androecial members. The petals are detached at a much higher level (Fig. 10). The larger posterior petal contains 7–9 bundles while each of the antero-laterals receives 4–5 strands.

The androecial members, even above the level of detachment of the petals, continue upward as a tubular structure. It is at a much higher level that the stamen is detached (Fig. 11). Still higher up, the lateral staminodes are separated from the labellum (Fig. 13). The stamen contains 5 bundles—a median, two prominent laterals which exhibit a double nature, and two tiny end traces (Fig. 11). The prominent laterals bear a few branches which establish as small strands in the connective (Fig. 12). The laterals lose their double nature. The connective is prolonged beyond the level of the anther and the vascular bundles extend into the crest although in a reduced state (Fig. 13). Within the composite anterior structure representing the labellum and the lateral staminodes, the bundles are arranged in a single row (Fig. 12). The lateral staminodes are detached above the level of the anther (Fig. 13). Each of them contains a median and 10–12 strands in addition. The labellum contains 25–30 bundles. There is no mid-anterior strand in the labellum. In its upper half, the labellum develops a median groove on its inner face (Fig. 13) which steadily deepens upwards splitting it into two equal segments.

**DISCUSSION**

The ground-plan of vascular supply to the flower in the present plant does not show any marked deviation from that of other studied species of the family. The inferior ovary wall is traversed by compound cords exhibiting varying degrees of fusion of the bundles belonging to different floral whorls. The inferior ovary may be considered to be a result of extreme degrees of adnation. A noteworthy feature is the reduction the carpellary dorsals have suffered. They end at the level of the plexus. In species of
Figs. 10-13. *Kaempferia rosea*—Serial transections of the upper part of the flower.

*Costus* (Rao *et al.*, 1954; Pai, 1962), *Alpinia* and *Catimbium* (Pai, 1956, 1962; Rao and Pai, 1959, 1960), the carpellary dorsals are continued into the style. In the present plant, the stylar supply is derived from the plexus.
Thompson's ontogenetical studies (1933) indicate the absence of carpels in the Scitamineae. Anatomical evidence, however, demonstrates the presence of the carpellary dorsal and the ventral system of bundles thus obviously pointing out that Thompson's view cannot be sustained (cf. Kojo-Poljansky, 1936).

The condition of the glands is interesting in that it indicates a trend towards elevation of the floral nectaries from a position within the ovary to one truly epigynous. In *Costus speciosus* Smith (Rao et al., 1954), and *C. malortieanus* Wendl. (Pai, 1962), the placental bundles in the upper part of the ovary are arranged in three groups, one posterior and two antero-lateral. These function as the vascular tissue of the glands developed at the inner ends of the septa of the ovary. However, the posterior gland is small and ends towards the top of the ovary while the two antero-laterals, enclosed in cavities, extend up to the base of the style. In the present plant, the placental bundles are also in three groups, in identical positions as in *Costus*, but the posterior group ends at the top of the ovary and the antero-laterals enter the glands lodged in cavities and developed just above the level of the plexus. The glandular tissue in the present plant develops at the level where that of *Costus* ends, and extends considerably upwards. In the great majority of the studied species of the family, the glands are antero-lateral, two in number, and are developed on top of the ovary much above the level of the plexus, and extending further upwards. But their vascular tissue is not comprised of the placental bundles. It is derived from the vascular plexus.

It seems that the flower of Zingiberaceae originally developed three nectaries, a condition in some way retained in *Costus*, but reduction of the posterior gland has occurred in the course of evolution. The development of the posterior gland, in addition to the antero-laterals in abnormal flowers of *Hitchenia caulina* Baker (Rao and Pai, 1959), may be interpreted as indicating a reversion to the ancestral state. The posterior group of placental strands in the present plant ends in the absence of a gland in that position. The usual occurrence of only two epigynous nectaries in many species of the family is thus explained.

It may also be pointed out that the nectaries originally developed within the ovary in positions comparable to those of the septal glands of the allied families—Musaceae, Cannaceae and the Marantaceae. In the present family, the fusion by margins of the carpels is complete and the septal nectaries are replaced by massive glandular emergences of carpellary tissue. If the carpellary ventrals merely flank the septal nectaries in the Cannaceae and the Marantaceae, their fusion product—the placental bundles actually enter
the glands in species of *Costus* and the plant under discussion of the Zingiberaceae. The presence of vascular tissue within the glands is on account of their more organized nature (cf. Esau, 1953). Furthermore, the development of the glands in the present species shows an intermediate stage in their elevation to an epigynous position. Coupled with this is the deviation in their vascular supply from the placental strands to the vascular tissue derived from the plexus. The epigynous position is thus a secondary derivation or for that matter a later attainment.

Brown (1938) studied the development of the nectaries in a number of families of flowering plants. According to him “in the family Zingiberaceae of the Zingiberales the characteristic nectaries are two long glands which project from positions where septal glands, if present, would be expected to discharge. In the simplest of the Zingiberaceae, the nectaries are typical septal glands” as in *Costus* wherein “........ the nectariferous tissue is at the bottom of the gland cavity and is dome-shaped. In more advanced genera, the dome-shaped tissue seems to have grown out into the elongated glands ....”. No doubt the glands in *Costus* are septal in position, but they are not septal nectaries in the current sense of the term (Rao et al., 1954; Eames, 1961). However, the present writer concurs with him in so far as he considers the epigynous position of the glands as a derived condition and the Costeae as the simplest of the Zingiberaceae. It has to be noted that in all taxonomic accounts (Loesener, 1930; Rendle, 1930; Hutchinson, 1959), the subfamily Costoideae or the tribe Costeae are treated at the beginning of the family.

In regard to the nature of the glands, it has been emphasized (Pai, 1961; Rao, 1963), that they are vascularized outgrowths of the ovary. That they are not just epidermal emergences as Gregory held for the cardamom flower has also been pointed out (Pai, 1965). The placental bundles constitute essentially a carpellary vascular tissue. When these same bundles function as the vascular tissue of the glands, it indicates that the glands and the ovary are closely connected organs of the flower of Zingiberaceae and precludes any possibility of their interpretation as modified members of the androecium.

In his recent interpretation (Pai, 1965), based on the course and the behaviour of the mid-anterior strand in the labellum, the present writer has pointed out that it does not represent the vascular supply of the dorsal stamen of the flower. Rather, it is a fusion product of the marginal traces of the two component members of the labellum belonging to the inner androecial whorl. In the present plant, the mid-anterior strand is not developed at all and laterally along the mid-anterior line are two strands which are continued
into the segments of the labellum. These, in plants like *Elettaria*, are fused to form a mid-anterior strand to give an erroneous impression that the dorsal stamen is represented in the flower and also implying thereby that the labellum is a triple structure (cf. Gregory, 1936). The present study testifies that the labellum is a double structure in accordance with the classical concept.

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**REFERENCES**