Egyptian J. Desert Res., 52, No.2 , 341-356 (2002)

FLORAL VASCULARIZATION OF *CHORISIA CRISPIFLORA* HBK (BOMBACACEAE) WITH A SPECIAL REFERENCE TO THE ANDROECIUM

Karima A. Hamed
Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt.

The floral vasculature of *Chorisia crispiflora* HBK was investigated for an anatomical interpretation to the androecial characters. The sepal receives one vascular trace and like such the petal is. The outer staminal whorl appears morphologically as five bifurcated more or less fleshy staminal phalanges. Anatomically, the phalanges receive ten traces; two to each. Radial splitting of the latter results in the occurrence of 20 bundles forming the total supply of this outer whorl. The inner staminal whorl is formed of a staminal column which is a fusion product of five filaments receiving five vascular traces. At the summit of the column, the five bundles are splitted to give ten bundles representing the supply to the ten anthers. Irrespective to the morphological aspects of both whorls, the stamens can be considered as anatomically indefinite; and thus polystemony can be applied. The term staminal phalanges applied to the outer stamens may be better substituted by the term "Staminodes" since the latter are vascularized. Obdiplostemony as well, is recorded in this species. The ovary supply is five carpellary ventral traces which supply the five carpels.

Keywords: c*horisia crispiflora* HBK, floral morphology, polystemony, staminodes.

Attention has long been paid to the androecia in the flowers for they are diverse in both number and position (Weberling, 1989 and Endress, 1994). The androecium in a flower with low stamen number may be either haplostemonous (stamens opposite the sepals) or obhaplostemonous (stamens opposite the petals). In both cases the stamens have the same number of sepals and/or petals to which they are anteposed. Diplostemonous androecium has two whorls of stamens; an outer antesepalous and an inner antepetalous (Hufford, 1998). This latter case is the typical one since the alternation sequence of the floral whorls is the rule. This sequence of alternation is broken by obdiplostemony where the outer staminal whorl becomes antepetalous and the inner whorl becomes antesepalous. In diplostemonous and obdiplostemonous androecia the stamen number equals the total number of the perianth parts. Where the stamen number exceeds the total number of perianth parts the androecium is described as polystemonous.

Polystemony, also known as polyandry, has been recorded in a number of families and categorized into the Papavaraceae type, the Cistaceae type and the Rosaceae type (Hirmer, 1918). Subsequent investigators (e.g. Tücker, 1972; Takhtajan, 1991) recognized the same three categories but identified them in terms of stamen initiation as helical (Papaveraceae), centrifugal (Cistaceae) and centripetal (Rosaceae).

Among the dicotyledonous taxa the malvalian complex is formed of the four core families Bombacaceae, Malvaceae, Sterculiaceae and Tiliaceae (Alverson *et al.*, 1998). Androecial characters that are well observed in these families are polystemony in Bombacaceae, Malvaceae and Tiliaceae (Wilson, 1937; Rao, 1952; Van Heel, 1966) and the occurrence of staminodes and obdiplostemony in Bombacaceae and Malvaceae (Rendle, 1952; Lawrence, 1963; Ronse Decraene and Smets, 1992).

As regards the Bombacaceae, a few work was done on the floral morphology in a few number of its species. Ronse Decraene and Smets (1992) described the outer staminal whorl as staminal phalanges. Nandi (1998), studying *Bombax* and *Bombacopsis*, gave it the term staminodes. A reference to double stamens, where one filament bears two anthers, has been done by Davis (1966) in *Bombax ceiba* and *B. albidum*. The same author (op. cit.) described the basal coalescence of the stamens into a short tube as well as the number of the staminal bundles.

However, the previous descriptions of the floral organs in the studied species of the Bombacaceae relied on the external (morphological) aspect of the different characters rather than their anatomical expression. So far as the present author is aware, no previous work was done on the flor vascularization of *Chorisia crispiflora* HBK. For this, the present work ai at studying the vascular make up of this species with a special reference polystemony.

MATERIALS AND METHODS

Flowers and flower buds of various sizes of *Chorisia crispifl* were collected from both the Botanic Garden, Faculty of Science, Ain Sh University and from some streets in Cairo, where the species is cultivated ornament and fixed in F.A.A. The customary methods of dehydrat infiltration, embedding (in paraffin wax), serial microtoming (at 10 – 12 and staining (with erythrosine-light green combination) were follo (Johansen, 1940). Photographs were taken on Kodak TMAX 100 film supplemented by explanatory drawings at the same magnifications.

OBSERVATIONS

A. Visual Investigation (Plate I)

The flower is pedicellate, bracteate, bracteolate, actinomorphic and hypogynous. Sepals united forming a leathery cup ending in 3-5 teeth. Petals five distinct, twisted, crumpled (crisped), five to six times as long as the calyx cup. Stamens united to form a staminal tube. The latter is formed of two parts; an outer basal part of relatively large five bifurcated structures termed staminodes or phalanges and an inner longer part of fertile stamens extending around the gynoecium and ending into ten connate anthers. Gynoecium of five united carpels, style terminal and single.

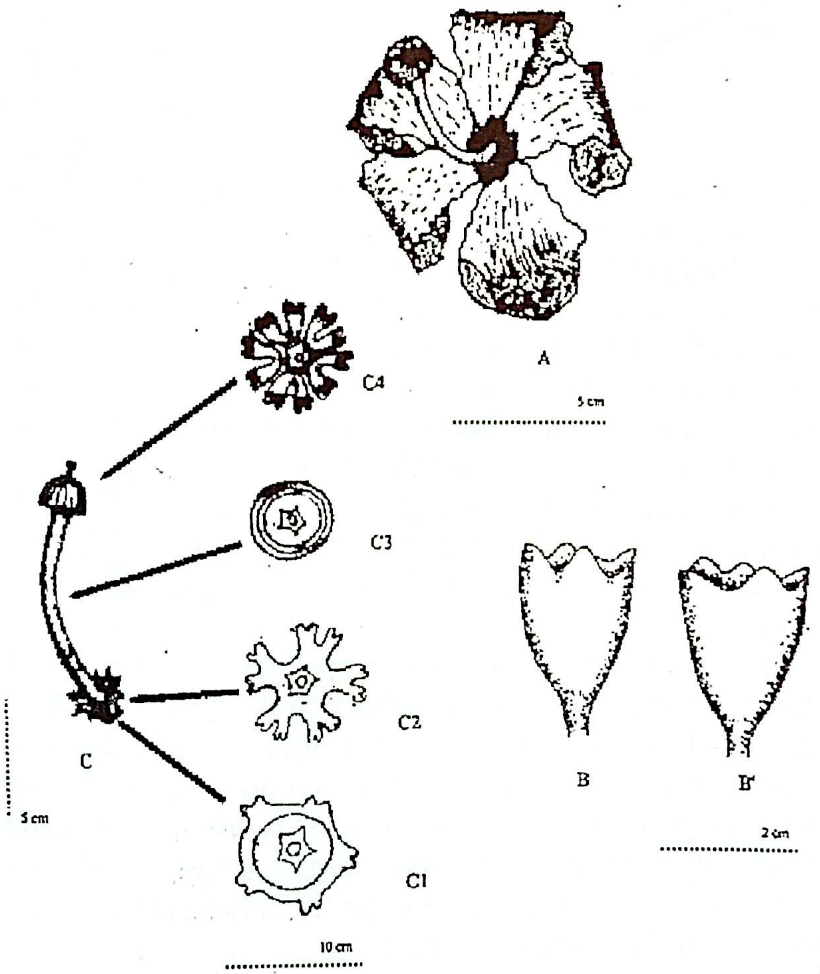

Plate I: (Figs. A-C): A, morphological aspects of *Chorisia crispiflora* flower; B&B', calyx cup (4-5 teeth); C, Staminal tube; C1-4, Diagrams of the staminal tube at different levels.

B. Anatomical Investigation (Plate II, Figs. A - V)

The vascular tissue of the receptacle is more or less a siphonostele (Fig. A). At a higher level five peripheral vascular complexes become differentiated and the rest of the siphonostele begins to differentiate to form the ovarian supply. Each of the peripheral complexes gives one trace to the inner antesepalous stamen (Fig. C). The residual tissue of this complex forms the sepal-petal-outer stamen supply. After the differentiation of the latter tissue, the central stele gives outer strands representing the carpellary wall supply and an inner ridged mass which will differentiate later into five fused carpellary ventral bundles (Figs. D-F). The vascular tissue representing the sepal-petal-outer stamen complex becomes differentiated into a sepal trace leaving a mass representing the petal-two outer stamens supply (Fig. H). The latter mass differentiates to give a median trace to the petal and two lateral traces to the outer stamens (Figs. H and I). At this level, a total of 25 vascular traces are detected. These are five to the sepals, five to the petals, ten to the outer stamens (Phalanges, Fig. M) and five to the inner stamens (Fig. I). Further development of the staminode gives it a massive aspect with the radial division of its two traces and becomes four (Figs. P and Q).

Morphologically, the inner staminal whorl appears as five fused filaments carrying ten anthers. Anatomically each of the inner five staminal traces becomes fragmented into a varied number of traces; some are circular and some others are in the form of bands, still others are urn-shaped (Figs. N, O and P). All these traces become finally aggregated to form five sets; each of three traces (Fig. Q), which become circumfrantially connected assuming a crescent-shaped mass (Fig. R). The ultimate ends of the crescent become radially stretched to enter two connate anthers (Fig. S). At more higher levels, the anthers become distinct and a total of ten anthers are detected (Figs. U and V).

The ovary supply is five fused carpellary ventral traces (Figs. D-F) and a fairly large number of carpellary wall traces (Figs. C-K). The carpellary dorsal traces are lacking. At a higher level each of the ventr bundles assumes a V-shaped mass with its two arms supplying the ovules of two adjacent carpels (Figs. G, H and I). What is left after the differentiation of the ovule supply represents the stylar supply (Figs. S – V). Towards the apex of the ovary the axile placenta becomes broken leaving the ovules on the carpellary margins (Figs. I, J and K).

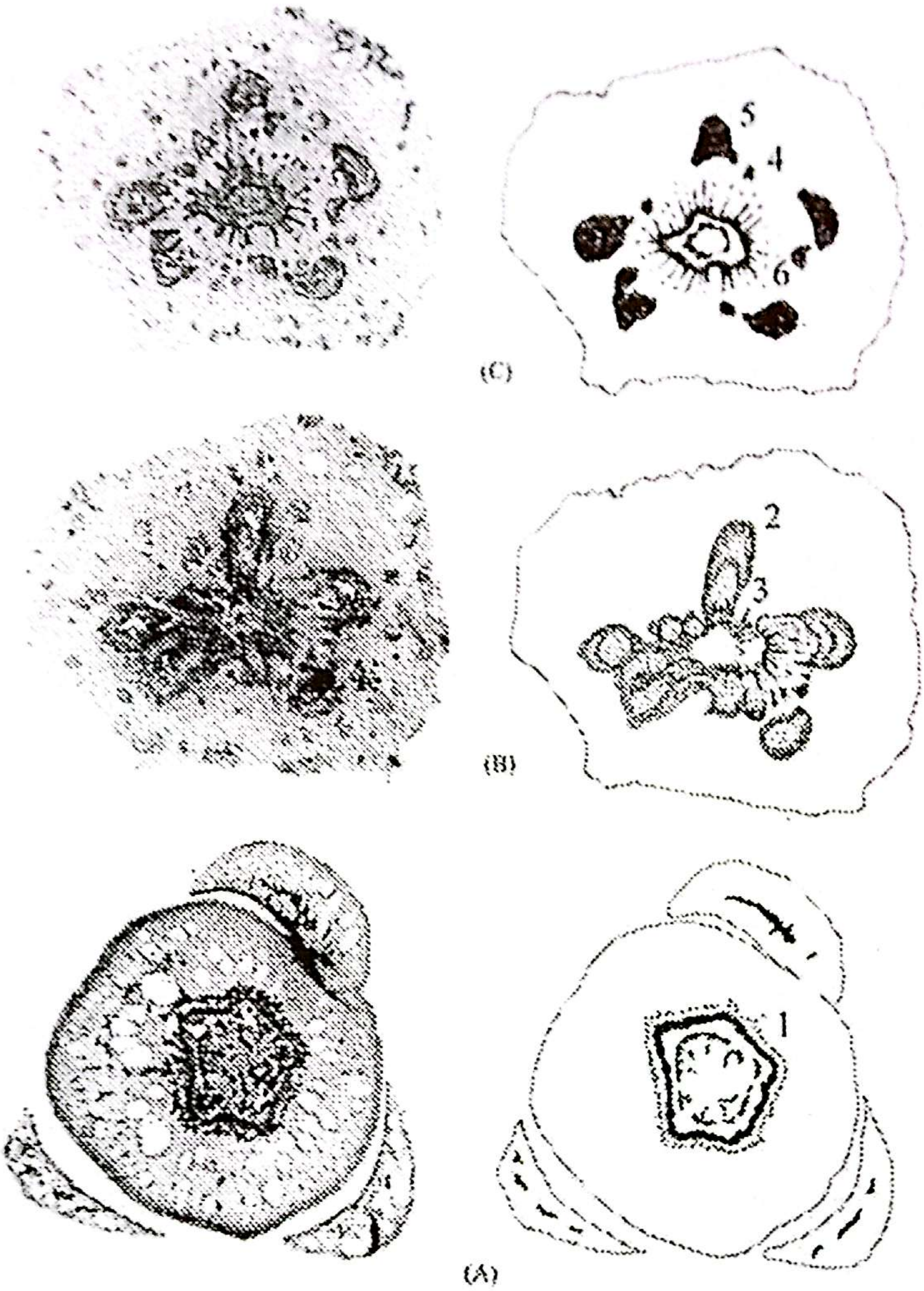

Plate II: Figs. A-C: Flora vascularization of *Chorisia crispiflora* (X 12).
Serial cross-sections from pedicel upwards.
1, siphonostele; 2, sepal-petal stamen complex; 3, ovarian supply; 4, inner stamen trace; 5, sepal-petal-outer stamen complex; 6, carpellary wall strands.

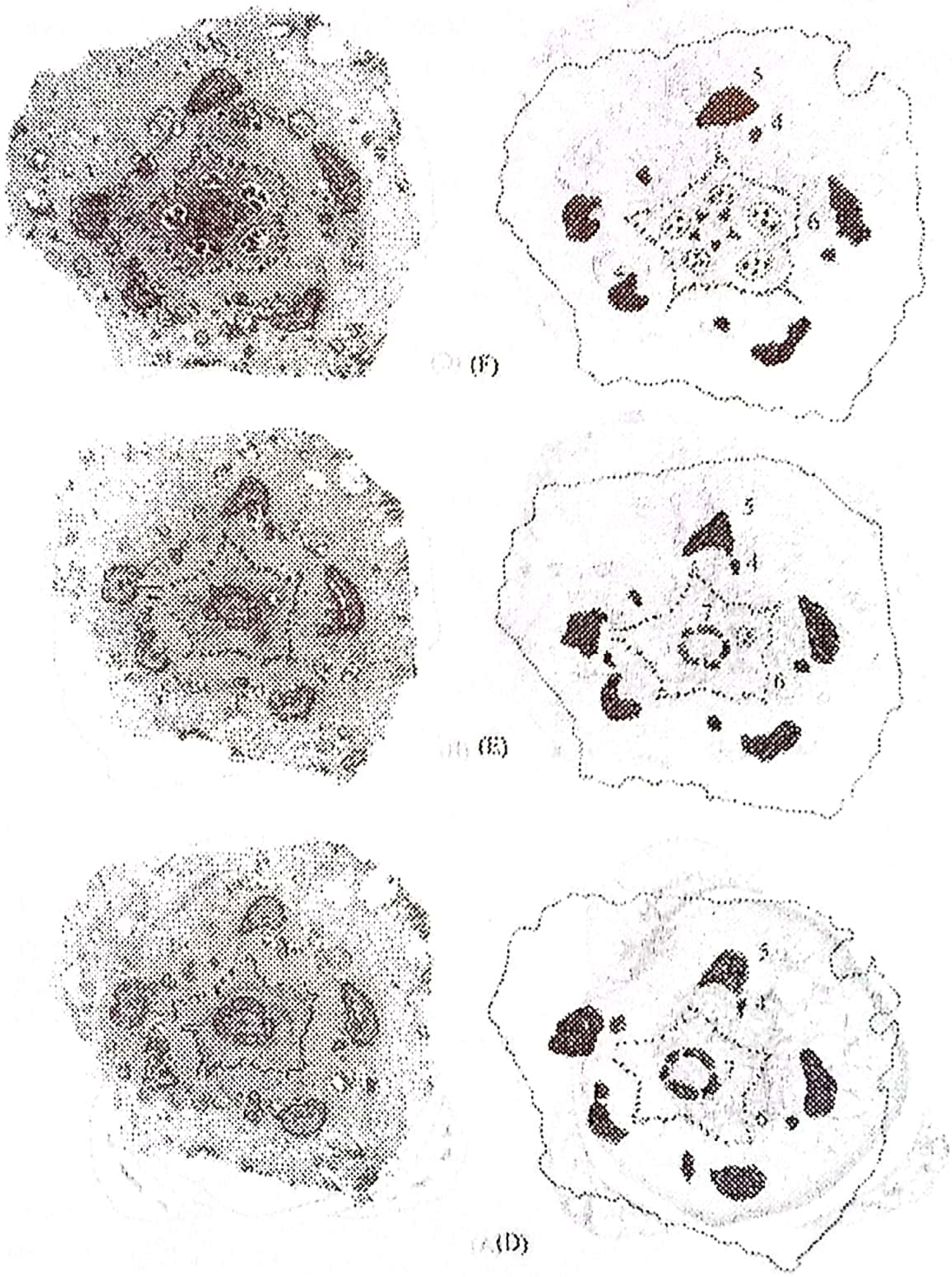

Plate II (cont'd): Figs. D-F: Flora vascularization of *Chorisia crispiflora* (X=12).
Serial cross-sections from pedicel upwards.
4, inner stamen trace; 5, sepal-petal stamen complex; 6, carpellary wall bundle; 7, fused ventral traces and fused ventral bundles.

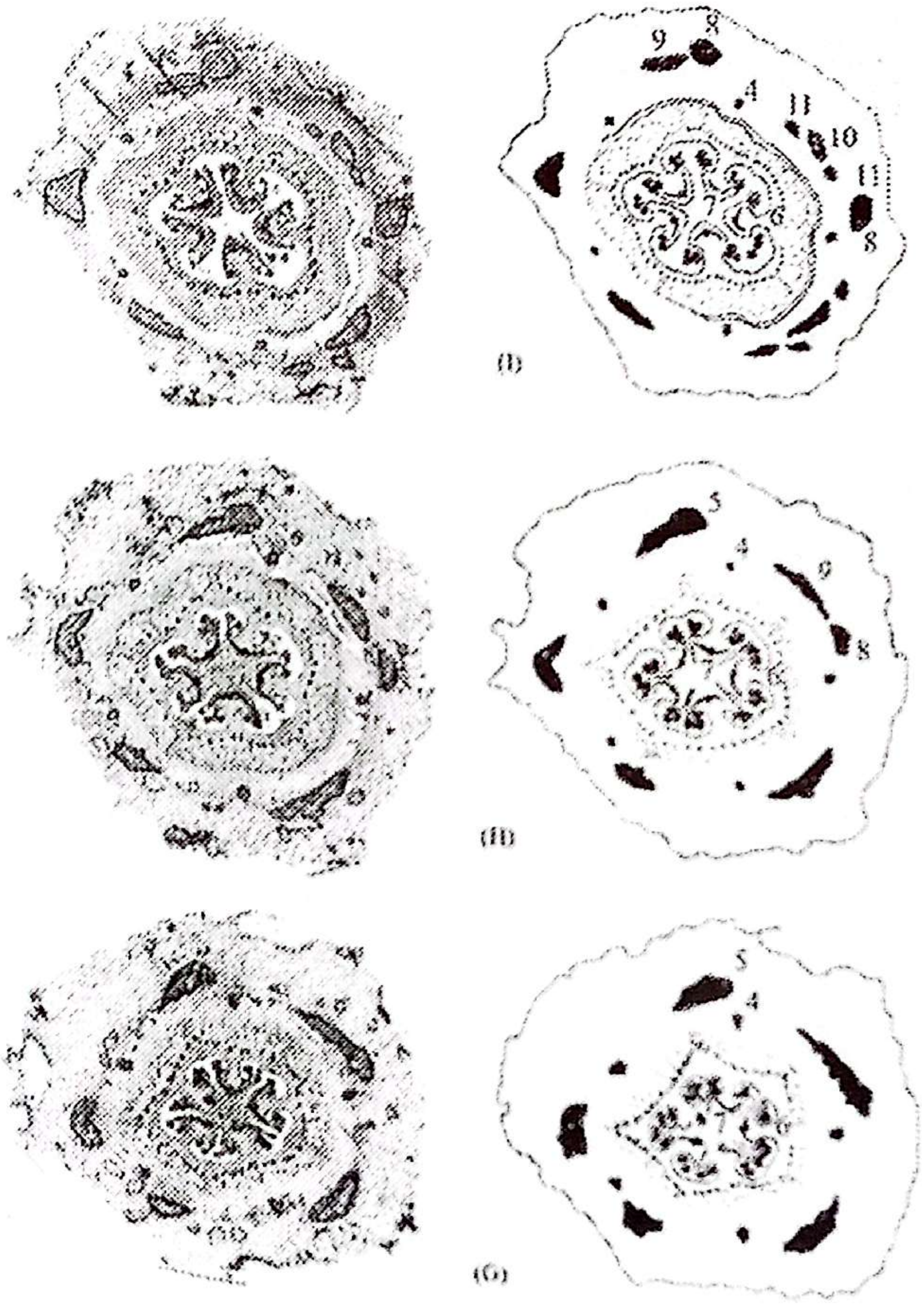

Plate II (cont'd): Figs. (G-I): Flora vascularization of *Chorisia crispiflora* (X=12).
Serial cross-sections from pedicel upwards.
4, inner stamen trace; 5, sepal-petal outer stamen complex; 6, carpellary wall bundles; 7, fused ventral bundle; 8, sepal trace; 9, petal-outer stamen complex; 10, petal trace; outer stamen traces. The placenta appeared axile in Figs. G and H, then broken and appeared parietal in Fig. (I).

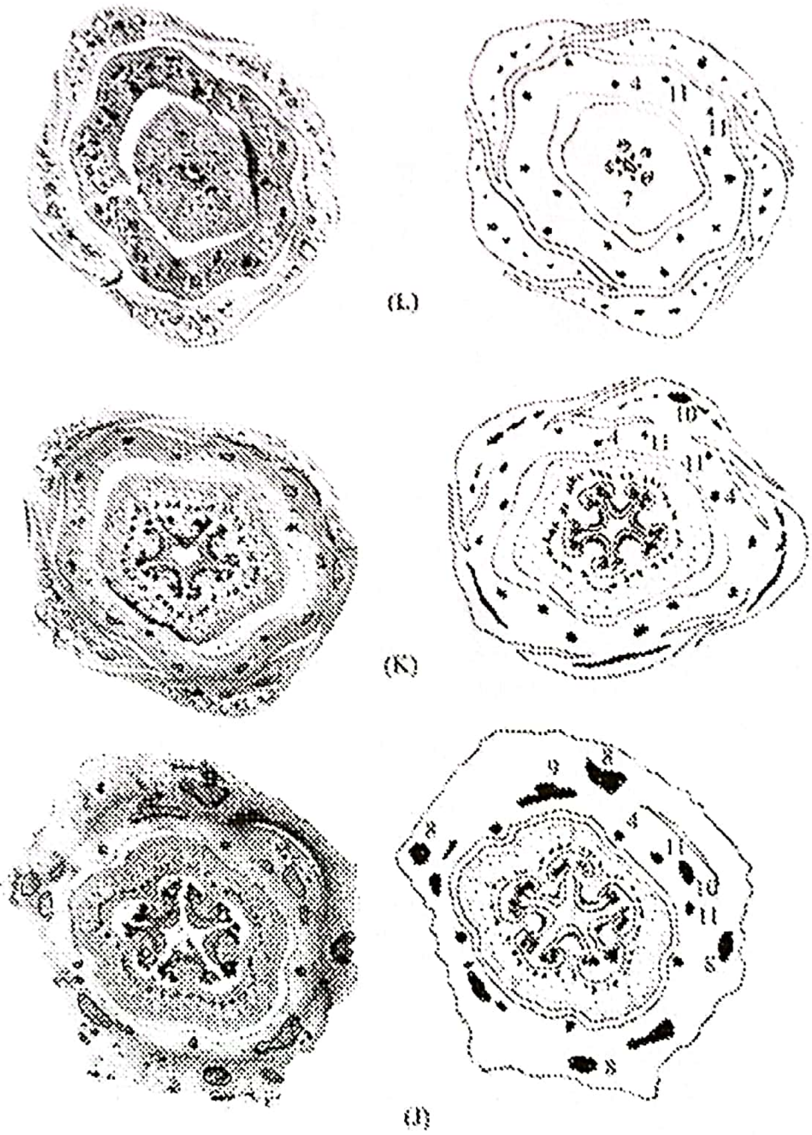

Plate II (cont'd): Figs. (J-L): Flora vascularization of *Chorisia crispiflora* (X=12).
Serial cross-sections from pedicel upwards.
(J), showing the separation of both the calyx cup and the ovary; (K), showing the ramification of petal bundle (calyx cup excluded); (L), showing the separation of both the staminal tube and the petals, the former containing fifteen bundle.
*** 4,7,8,9,10 and 11 the same as mentioned in Fig. (H-I).**

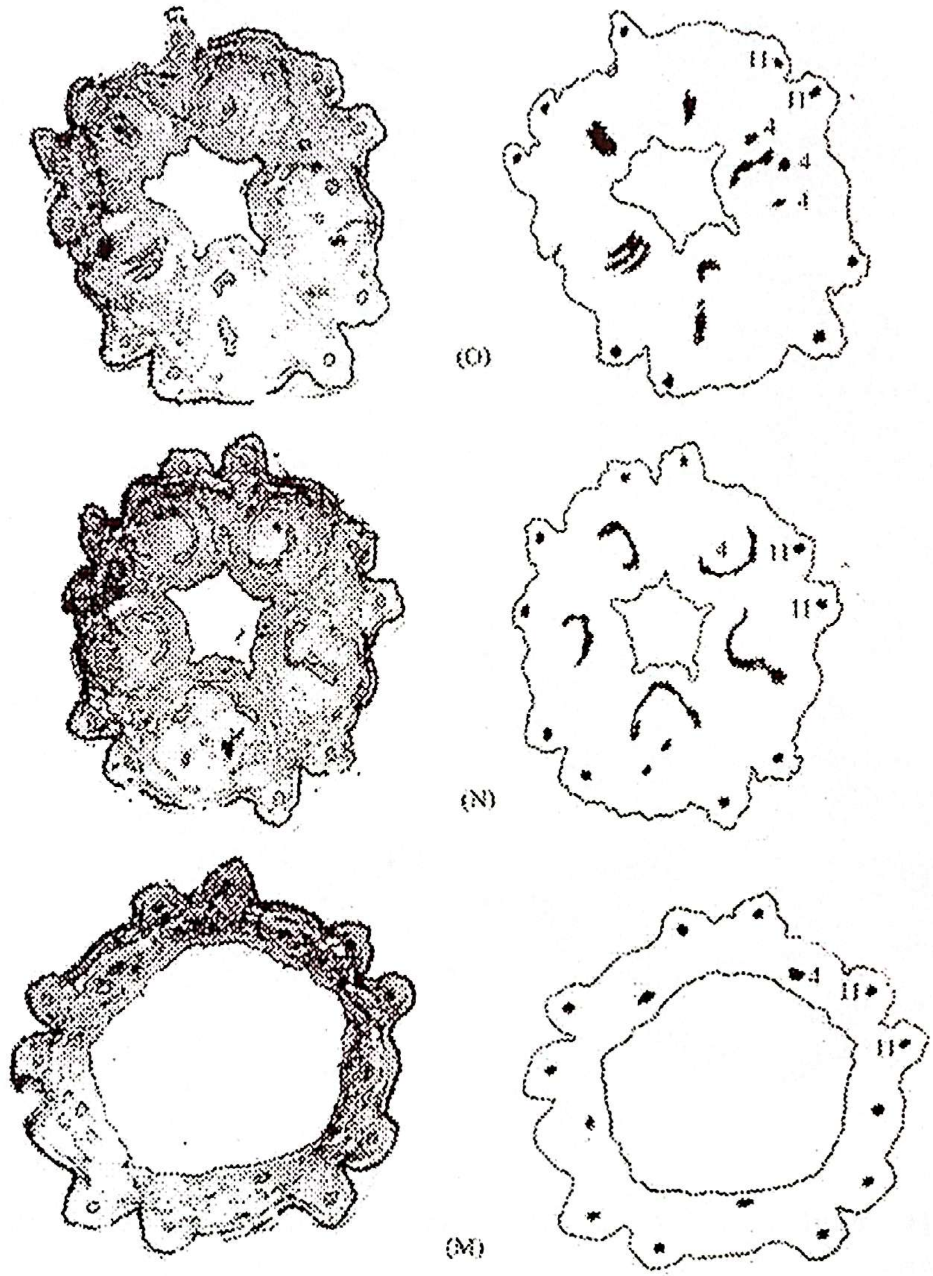

Plate II (cont'd): Figs. (M-O): Flora vascularization of *Chorisia crispiflora* (X=5).
Serial cross-sections in the staminal tube (other flora parts excluded). 4, inner staminal bundle (note the fragmentation); 11, outer staminal bundles (std. staminode).

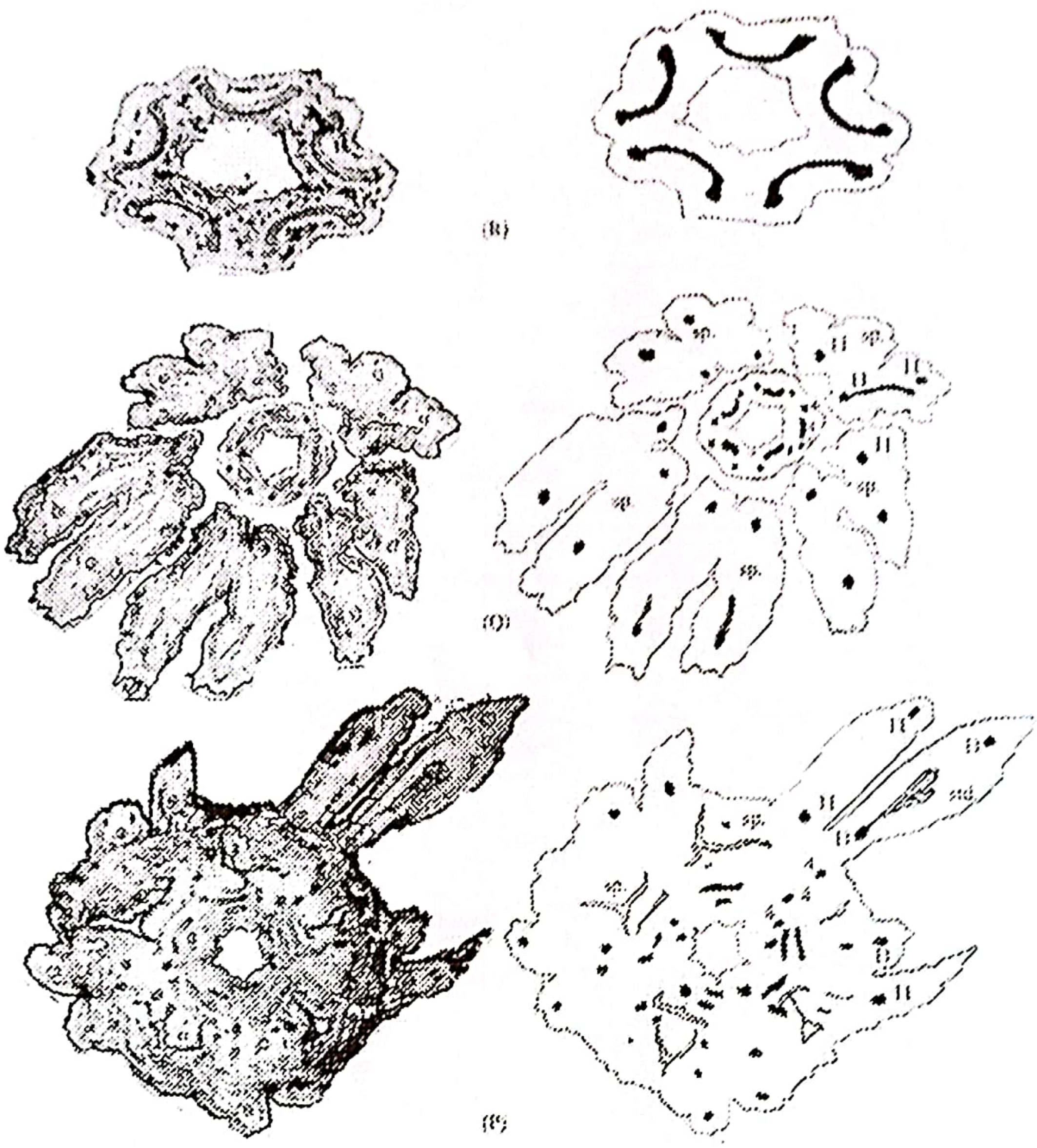

Plate II (cont'd): Figs. (P-R): Flora vascularization of *Chorisia crispiflora*.
Serial cross-sections in staminal tube.
P, radial division of the outer staminodal bundle, 11, in the staminodes; std, separation zones (sp.) of the staminodes observed (X=10); Q, the complete separation of the staminodes (X=10); R, inner staminal tube (outer staminods excluded, X=20).
Where 4 and 11 the same as mentioned in Fig. (H-I).

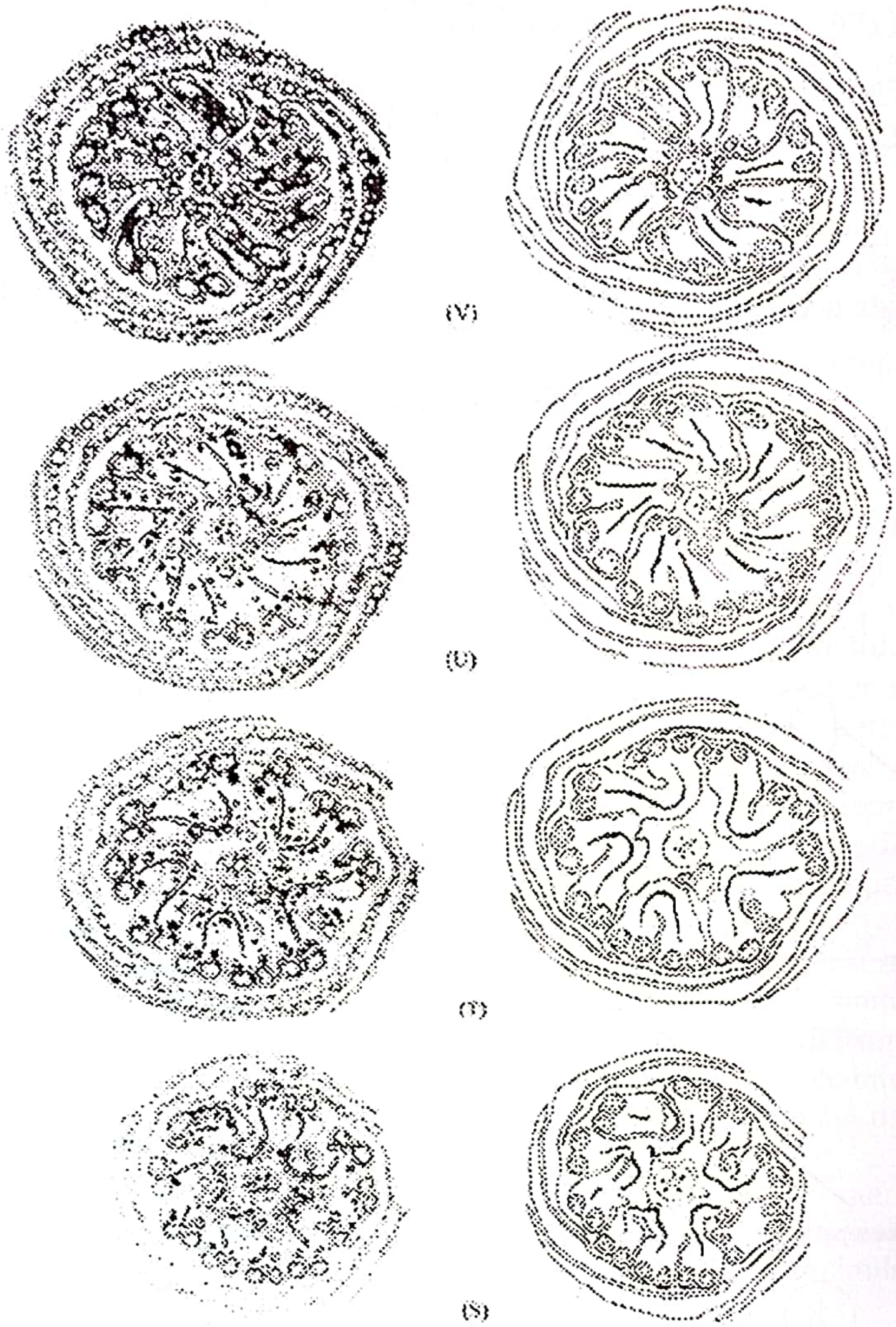

Plate II (cont'd): Figs. (S-V): Flora vascularization of *Chorisia crispiflora* (X=10).
Showing all the flora organs except the calyx cup; S, showing the vascularization of the fertile stamens (inner stamens); T, showing diads of stamens (each of one common filament bearing two fused anthers); U, showing a stage of splitting of fusion of anthers; V, complete separation of anthers (appearing as ten anthers equivalent to the ten stamens).

DISCUSSION

The present observations show that the divergence of the traces took place in the following sequence. The first to differentiate were the traces to the inner antesepalous stamens. This was followed by the differentiation of the sepal traces from sepal-petal-outer stamens complexes. The petal traces were differentiated from petal-outer stamen complexes. The last to differentiate was the outer antepetalous staminal traces (Plate III).

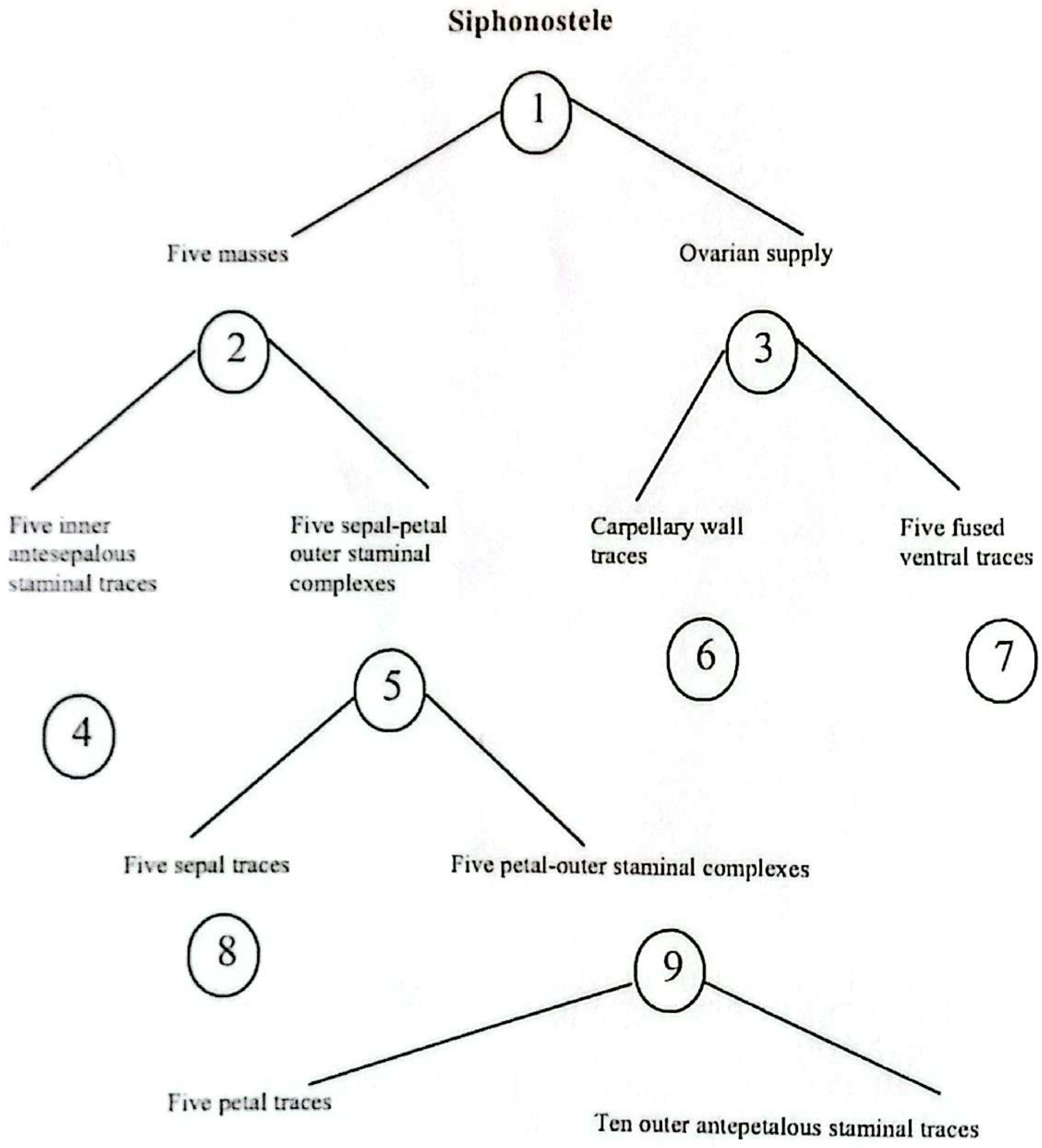

Plate III: Diagrammatic presentation showing the floral vasculature in *Chorisia crispiflora* HBK. (The numbers indicate the sequence of differentiation of the different floral traces and are the same as given in Plate II).

Adnation of the vascular supply of sepal, petal and stamen recorded in the present work was also recorded by Murty and Gaur (1971) in some Malvales. The divergence of the inner antesepalous staminal traces earlier than the laterally adjacent staminal traces (outer antepetalous) was recorded in *Pachira* (Bombacaceae) by Van Heel (1966). Not only a similar case was recorded in this work but also the inner antesepalous staminal traces diverge even earlier than those to the sepals, petals and the outer antepetalous staminal traces. As to the number of traces to sepals and petals, the present data shows one trace to each. However, Rao (1949, 1952 and 1953) stated that the sepal and petal in Malvales appear to be three-traced except for some few species.

The petal-outer antepetalous stamen complex has been named differently by different workers. Wilson (1937) described it as a fascicle (in both Malvaceae and Bombacaceae) and Davis and Kundu (1965) named it cord (in *Ceiba pentandra*, Bombacaceae). As to the mode of its splitting there has been two views. The first is that of Rao (1949 and 1952) who stated that in different representatives of Malvales, the complex divides firstly into two parts; an outer trace to the petal and an inner one to the stamen; the latter undergoes further splitting resulting in an indefinite number of staminal traces. The other view of splitting is that of Wilson (1937) who stated that in Malvaceae and Bombacaceae, the complex splits into three traces; the median for the petal and the two laterals for the two antepetalous stamens. In the present study, the splitting of the petal-stamen complex is in agreement with that of Wilson (1937).

As regards the stamens, a process of splitting occurred in the vascular traces to both outer and inner stamens. The outer staminal traces were amplified from ten to 20 traces; the latter represent the supply of the five bifurcated staminodes (Phalanges). In the inner staminal traces, progressive splitting occurred starting from five to an ultimate of ten traces which represent the supply of five fertile stamens.

That the fertile stamens are morphologically five in number with a double number of traces directed the attention towards their consideration as stamen pairs. Ronse Decraene and Smets (1992), recorded similar staminal pairs in Bombacaceae.

Regardless of fertility, the outer non-functional stamens could better be termed staminodes since they are vascularized. The term "Phalanges" applied to them may be rejected on account that such structures are non-vascularized. Moreover, and irrespective to the morphological aspect of both the non-functional and functional stamens the andoroecium in *Chorisia crispiflora* could be considered as anatomically indefinite; and hence polystemony can be assigned to this species. Obdiplostemony in other species of Malvales recorded by Rao (1952), Murty and Gaur (1971) and Ronse Decraene and Smets (1992) was also recorded in this work.

ACKNOWLEDGEMENTS

The author is much grateful to Prof. Dr. A. S. Al-Nowaihi for his vital advise and continuous encouragement and to Dr. M. M. Mourad for his help.

REFERENCES

Alverson, W. S.; K. G. Karol; D. A. Baum; M. W. Chase; S. M. Swensen; R. McCourt and K. J. Systma (1998). Circumscription of the Malvales and relationships to other Rosoidae: Evidence from rbcl sequence data. *Amer. J. Bot.*, 85: 876.

Davis, T. A. (1966). Floral structure and stamens in *Bombax ceiba* L. *J. Genetics*, 59 : 294-328.

Davis, T. A. and A. Kundu (1965). Floral structure and stamens in *Ceiba pentandra* (Linn.) Gaertin. *J. Bombay Nat. Hist. Soc.*, 62 (3): 394-411.

Endress, P. K. (1994). Floral phyllotaxis and floral evolution. Botanische Jahrbücher für systematische. *Pflanzengeschichte und pflanzengeographie*, 108: 417-438.

Hirmer, M. (1918). Beiträge zur morphologie der polyandrischen blüten. *Flora*, 110: 140 – 192.

Hufford, L. (1998). Early development of androecia in polystemonous Hydrangeaceae. *Amer. J. Bot.*, 85(9): 1057-1067.

Johansen, D. A. (1940). In "*Plant Microtechnique*". New York Book Comp., 553 pp.

Lawrence, G. H. M. (1963). In "*Taxonomy of vascular plants*". The Macmillan Comp., New York, 833 pp.

Murty, Y. S. and R.D. Gaur (1971). Floral anatomy of some species of *Corchorus*. *J. Indian Bot. Soc.*, A: 130-140.

Nandi, O. I. (1998). Floral development and systematics of Cistaceae. *Pl. Syst. Evol.*, 212: 107-134.

Rao, C. V. (1953). Floral anatomy and embryology of two species of *Elaeoearpus*. *Ibid.*, 32: 21-34.

Rao, C. V. (1952). Floral anatomy of some Malvales and its bearing on the affinities of families included in the order. *Ibid.*, 31: 171-203.

Rao, C. V. (1949). Floral anatomy of some Sterculiaceae with special reference to the position of stamens. *J. Indian Bot. Soc.*, 28: 237-245.

Rendle, A. B. (1952). In "*The Classification of Flowering Plants*". Vol. II Dicotyledoneae. Camb. Univ. Press. (7th ed.), 636 pp.

Ronse Decraene, L. P. and E. Smets (1992). Complex polyandry in the Magnoliatae: definition, distribution and systematic value. *Nord. J. Bot.*, 12: 621-649.

Takhtajan, A. (1991). In "*Evolutionary trends in flowering plants*". Columbia Unvi. Press, New York.

Tücker, S. C. (1972). In "*The role of ontogenetic evidence in floral morphology*". In Y. S. Murty, B. M. Johri, H. Y. Mohan Ram, and T. M. Varghese, Nauchandi, India.

Van Heel, W. A. (1966). Morphology of the androecium in Malvales. *Blumea*, 13: 177-394.

Weberling, F. (1989). In "*Morphology of flowers and inflorescences*". Camb. Univ. Press, Cambridge, UK.

Wilson, C.L. (1937). The phylogeny of the stamen. *Amer. J. Bot.*, 24: 686-699

Received: 03/09/2002
Accepted: 08/03/2003

التركيب الوعائي الزهري للنوع *Chorisia crispiflora* HBK مع الاشارة الخاصة إلي خصائص الطلع

كريمه عبد الخالق حامد
قسم النبات – كلية العلوم – جامعة عين شمس – القاهرة – مصر.

تم دراسة التركيب الوعائي لزهرة النوع *Chorisia crispiflora* HBK لدراسة المدد الوعائي للأعضاء الزهرية عامة مع التركيز علي ذلك الذي يغذي الطلع من أجل تفسير لمورفولوجيته علي أساس تشريحي وسجل وجود حزمة وعائية واحدة لكل من السبلة والبتلة، وخمس حزم بطنية تغذي الكربلات الخمس التى ينقصها وجود الحزم الظهرية. ووجد أن الأسدية تلتحم لتكون أنبوبة سدائية تعبر عن نفسها مظهريا بجزء سفلي خارجي يقابل البتلات ويتكون من خمس تراكيب لحمية (Phalanges) مشقوقة تتغذي بعشر حزم وعائيه تنقسم قطريا عند دخولها الزوائد إلي عشرين حزمة، وجزء علوي داخلي يقابل السبلات ويتكون من خمسة خيوط ملتحمة تنتهي بعشرة متوك، متكان لكل خيط ، وجميعها تتغذي بخمس حزم تنقسم الي عشرة عند دخولها المتوك.

وخلص البحث إلي أن الطلع يعتبر عديد الاسدية Polystemonous من الناحية التشريحية وأنه من الأفضل ان يستبدل اللفظ " تراكيب لحمية Phalanges " باللفظ " الأسدية العقيمة Staminodes" لأن الاخيرة لها مدد وعائي ، كما سجلت ظاهرة الازدواج الطلعي (التقابل الازدواجي) Obdiplostemony في هذا النوع قيد الدراسة.