

STUDIES IN THE TUBIFLORAE OF NAGPUR

III. A CARPOLOGICAL STUDY

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ABSTRACT

The paper presents results of a carpological study of the Tubiflorae of Nagpur based on author's personal acquaintance with more than 150 local species belonging to fourteen out of fifteen Indian plant families of the order. The "syncarpellous, epichlamydous" fruit has a persistent calyx that often exhibits a diagnostic form. Drupe, berry, capsule and schizocarp are the four principal types. Nine families may be broadly classed as "monocarpi" and the remaining five as "bicarpic". Distribution of these fruit types in the order offers no clue to their relative antiquity. While a broad correlation may be seen between fruit type and habit, exceptions are not wanting. Taxonomic value of fruit characters and inadequacies in the existing system of classification of fruits have been discussed. While existence throughout the order of a fundamentally uniform fruit-type adds weight to the view that "the Tubiflorae form a natural group", the several variations of this type indicate lines of specialisation within this large taxon.

INTRODUCTION

The flowering plants are commonly set apart from others by enclosure of their seeds. The fruit, therefore, is one of the distinguishing characters of the "angiosperms". And yet, it is surprising that little attention has been paid to carpological studies of plant groups. Hitchcock (1925) states that "a careful study of fruits and seeds has never been made in connection with a local flora in this country (America)". He points out the desirability of studying the morphology of fruits and seeds, their methods of dispersal, and, as far as possible, the connection between the two.

The taxonomic value of fruit characters has been acknowledged by various authors. Lawrence (1951) points out that "fruits are important in the classification, delimitation and identification of seed plants because generally they provide characters very reliable in the characterisation of genera and species". Eames (1961) observes that "most classifications of fruits have been proposed for taxonomic purposes and, as such, are important".

The phylogenetic importance of fruit has been stressed by many. Sinnott and Bailey (1915) and Corner (1949), among others, have tried to establish a correlation between habit and fruit-type, and, thereby, have expressed views on the primitive forms of both.

Ridley (1930) has described at length the role of fruits in ecology and distribution of angiosperms.

As regards the Indian Tubiflorae, fruit characters have been successfully employed at various taxonomic levels by previous workers. For instance, Clarke (1883) divides the Solanaceae into four sub-families ("sub-orders") using fruit-type as one of the distinguishing features; dehiscence of fruit and texture of pericarp are utilised by Cooke (1905) as key characters for the genera of the Convolvulaceae; Mukerjee (1940) distinguishes species of *Lindernia* on the basis of relative length of calyx and fruit.

Despite this practical utility of fruit as a convenient key character, there is no unanimity regarding its definition and classification. The attempts of Dickson (1871), Masters (1871), Winkler (1939) and Egler (1943), among others, are noteworthy. Esau (1953) remarks that "it seems timely that these ambiguous designations be replaced by terms that reflect the basic structure of the flower from which the fruits are derived". She recommends Winkler's (1939) definition and classification as "worthy of attention". Eames (l.c.) observes that "classifications of fruits are largely or wholly artificial".

THE TUBIFLORAE OF NAGPUR

The Tubiflorae are a dicotyledonous taxon characterised by sympetalous, tetracyclic, hypogynous, bisexual flowers. Engler and Diels (1936) envisage the order to be composed of twenty-two families. Accepting this circumscription of families constituting the order, fifteen of them are represented in the flora of our country. Of these, fourteen occur in the neighbourhood of Nagpur. They include six small families which are each represented by a single genus—Polemoniaceae (*Phlox*), Hydrophyllaceae (*Hydrolea*), Orobanchaceae (*Orobanche*), Lentibulariaceae (*Utricularia*), Pedaliaceae (*Sesamum*) and Martyniaceae (*Martynia*). All tribes of Boraginaceae, Bignoniaceae, Verbenaceae and Acanthaceae and two-thirds of those of Convolvulaceae, Solanaceae, Scrophulariaceae and Labiatae have their one or more representatives in the Nagpur flora. Studies based on these local members of the Tubiflorae would, therefore, give us an adequately representative picture of the characteristics of the entire taxon. The present attempt is to bring out the diversity of fruit characters met with in this large group and to indicate their value in taxonomic study. The account presented here is based on the author's personal observations on the fruits of over 150 local species of the group.

THE FRUIT

The fruit in the Tubiflorae is the product of the ripened gynoeceum. Using Winkler's system (i.c.), it may be conveniently designated as the "syncarpellous, epichlamydous" type (fig. 1).

Another characteristic feature of the fruit, which is universal in the whole taxon, is the possession of the persistent calyx. The duration for which the calyx may persist varies. In some (e.g. *Ipomoea*, *Mazus*, *Thunbergia*) it persists till dehiscence of fruit, while in others, e.g. *Kigelia*, *Martynia*, it falls off rather early. The persistent calyx is often accrescent, and may serve to protect the fruit by enveloping it completely, as in *Physalis*, *Withania* (fig. 36) and *Tectona* (fig. 55), or, it may aid in fruit dispersal e.g. *Trichodesma* (fig. 24), *Solanum xanthocarpum* (fig. 37).

GYNAECEUM IN THE TUBIFLORAE

Apart from the common fundamental fruit-type and universality of persistent calyx, fruits of this order exhibit several variations of detail.

For a correct appraisal of the diversity exhibited by fruits of the Tubiflorae, it is necessary to trace the correlation between various features of mature fruit with form and structure of gynaeceum. The gynaeceum in this order is typically superior, bicarpellary and syncarpous. The two carpels are placed antero-posteriorly (oblique in the Solanaceae) and the ovary is generally bilocular, showing axile placentation (fig. 12). The mature fruit is a two-chambered berry (e.g. *Physalis*) or capsule (e.g. *Merremia*). The number of ovules in each loculus of the ovary may be one (figs. 9, 10), two (fig. 11) or many (fig. 12), so that the fruit may be two-, four- or many-seeded as in *Blepharis*, *Rungia* and *Antirrhinum* respectively. The arrangement of ovules may be uni-, bi- or multi-seriate in each loculus, leading to a corresponding disposition of seeds in the fruit (e.g. *Hygrophila*, *Thunbergia*, *Kickxia*).

The bilocular ovary may become tetralocular by false septation (figs. 13-16). Here the fruit may be a capsule, with four (e.g. *Ipomoea quamoclit*) or many (e.g. *Sesamum indicum*) seeds, berry (e.g. *Argyrea*), drupe or schizocarp. The drupe may have a four- to one-chambered "stone" (e.g. *Premna herbacea*) or it may contain 4-1 "stones" which are one-chambered (e.g. *Clerodendrum serratum*). The development of schizocarp dehiscing into two to four mericarps, observed in certain members of the Boraginaceae (e.g. *Trichodesma*) is a tendency towards specialisation of fruits which has become fixed in the family Labiatae where the fruit is universally a carcerulus.

In some genera the bicarpellary ovary is unilocular and shows parietal (fig. 18), parietal and marginal (fig. 19) or free central (fig. 17) placentation. The resultant capsule may be one-chambered (e.g. *Utricularia*, *Dopatrium*, *Orobanchae*) or may become

two- or four-chambered (e.g. *Martynia*) owing to fusion of parietal placentae in the centre.

In *Phlox* the ovary is tricarpellary, trilocular, with a single axile ovule in each loculus (fig. 20). The fruit is a three-seeded capsule. The tetracarpellary syncarpous ovary in *Duranta* becomes eight-locular, by false septation, with one ovule in each loculus (fig. 21). The drupe contains four two-seeded pyrenes.

Besides these fundamental differences in composition and structure of gynaeceum, features of external morphology often determine some of the characteristics of mature fruit. Stipitate (fig. 2) or sessile (fig. 4) nature of the ovary, its even or lobed (fig. 6) outline, globose (e.g. *Solanum*) or elongate (e.g. *Kigelia*) shape, glabrous (fig. 2), pubescent (e.g. *Thunbergia fragrans*), hairy (fig. 3), glandular pubescent (fig. 4) or spiny (fig. 5) surface of its wall and gynobasic (fig. 6), terminal (fig. 7) or subterminal (fig. 8) position of the style and its deciduous (e.g. *Crossandra infundibuliformis*) or persistent (e.g. *Utricularia*, *Heliotropium indicum*) character lend distinctive features to fruits. Papillose (e.g. *Elytaria*) or retinaculate (e.g. *Hemigraphis*) form of placentas is helpful in distinguishing fruits of the Acanthaceae.

It must be admitted, however, that some of the morphological features of ovary may be obliterated in mature fruit; shape may not be retained, size may alter and degree of certain characters like pubescence may not remain constant. Separation of exocarp and endocarp in capsules (e.g. *Martynia*, *Operculina turpethum*) and isolation of individual loculi in schizocarps (e.g. *Heliotropium*, *Stachytarpheta*) may take place only when fruit matures.

FRUIT TYPES AND THEIR DISTRIBUTION

Drupe, berry, capsule and schizocarp are the four principal types of fruits met with in the Tubiflorae. On the basis of distribution of these four types, the constituent families fall into two categories: (i) "monocarpic", characterised by only one type of fruit, and (ii) "bicarpic" exhibiting two fruit types.

The "monocarpic" families include nine out of the fourteen local families of this order. The Martyniaceae possess the characteristic drupaceous capsule with horned endocarp. In the Labiatae, as pointed out earlier, the fruit is typically a carcerulus. The remaining seven families, viz., Polemoniaceae, Hydrophyllaceae, Scrophulariaceae, Orobanchaceae, Lentibulariaceae, Pedaliaceae and Acanthaceae are characterised by the presence of a capsule.

Five local families come under the category of "bicarpic" families. Of these, three, viz., Convolvulaceae, Solanaceae and Bignoniaceae, show berry (e.g. *Argyrea*, *Withania*, *Kigelia*) and capsule (e.g. *Merremia*, *Datura*, *Doxantha*); while, in the remaining two families, viz., Boraginaceae and Verbenaceae, we come across drupe (e.g. *Cordia*, *Tectona*) and schizocarp (e.g. *Trichodesma*, *Stachytarpheta*).

Eames (l.c.) remarks that "the range in fruit within a family may be great". The above analysis shows that this is not true for the families of the Tubiflorae. The principal fruit-types met with in the order are only four. The majority of families are "monocarpic"; the rest are only "bicarpic". Even among the latter, the pairing of fruit-types is in two ways, each being characteristic of a small group of families. Within a genus, the fruit type is constant. Variations in shape, size, structure, dehiscence and seed number do exist. These can be successfully employed as specific key characters.

FRUIT TYPE AND HABIT

According to Eames (l.c.), "trees and shrubs and climbing plants tend to have large and fleshy fruits; terrestrial herbs nearly always have small, dry fruits". A broad correlation of this type may be said to exist in the Tubiflorae. Arboreal members, like *Cordia* (drupe), *Kigelia* (berry) have fleshy fruits, the berries of *Kigelia* being especially very big. *Lantana camara* and *Duranta repens*, which tend to be arborescent, produce small drupes. The woody twiners of the Convolvulaceae, viz., *Rivea hypocrateriformis* and *Argyrea nervosa*, have berries that become dry and hard at maturity. The order consists mostly of herbs and these have small dry fruits like the capsule (e.g. *Phlox*, *Gantelbua urens*) or schizocarp (e.g. *Coldenia procumbens*, *Salvia plebeia*).

It must at the same time be pointed out that the herbaceous species of *Solanum* (e.g. *S. nigrum*) and *Physalis* (e.g. *P. minima*) have berries, while the low-growing *Premna herbacea* produces drupes. The twining species of Convolvulaceae and Bignoniaceae (e.g. *Jacquemontia paniculata*, *Doxantha unguis-cati*) exhibit the dry capsule. Some of the herbaceous members tend to be suffruticose or shrubby. These may bear dry fruits like the cerculus in *Leonotis nepetaefolia* and capsule in *Datura metel* or fleshy ones like the drupe in *Clerodendrum serratum*. *Dolichandrone falcata*, a tree member of the Bignoniaceae, produces a falcate, bivalved capsule.

FRUIT TYPE AND PHYLOGENY

It is not possible to associate any one of the four principal types of fruit exclusively with families that have otherwise been considered as either primitive or advanced. The capsule is prevalent both in the Convolvulaceae and the Acanthaceae; the schizocarp is met with in the Boraginaceae as well as in the Verbenaceae and the Labiatae; the berry is seen in the Convolvulaceae and the Solanaceae as also in the Bignoniaceae; the drupe is exhibited by both the Boraginaceae and the Verbenaceae. If succulent fruits are considered more primitive than dry ones and if the schizocarp is regarded as more specialised than the capsule, it may be said that evolution of fruit-types has occurred more than

once in the Tubiflorae and that certain families like Boraginaceae and Verbenaceae have retained the primitive fruit-type in some of their members while they evolved the specialised one in others.

FRUITS IN FAMILIES OF THE TUBIFLORAE

1. Polemoniaceae: This small family is represented locally by a single species, *Phlox drummondii*, which is cultivated in gardens. The globose capsule has a thin and membranous pericarp (fig. 22).

2. Hydrophyllaceae: There is only one member of this family in India, viz., *Hydrolea zeylanica*. In this species, the capsule is two-chambered and dehisces septically (fig. 23), leaving the placentiferous dissepiment in the centre.

3. Boraginaceae: The drupe distinguishes *Cordia* (figs. 28, 29) from the other three local genera, viz., *Coldenia*, *Heliotropium* (fig. 27) and *Trichodesma* (fig. 24) which produce schizocarps. The number of mature fruitlets may be reduced by abortion (e.g. *Trichodesma*, *Heliotropium supinum*). The nutlet often exhibits certain specific characters. In *Trichodesma* the inner face shows diagnostic features (figs. 25, 26). Species of *Heliotropium* can be distinguished by the character of the back of the nutlet.

The fruit is thus a very useful character in the Boraginaceae. "Most taxonomic treatments are based on fruit or nutlet characters, and fruiting material is almost essential to critical identification" (Lawrence, l.c.).

4. Convolvulaceae: In this family, fruit characters are helpful in distinguishing genera and species (see Cooke, l.c.; Haines, 1922). While the capsule (fig. 30) is the most prevalent type of fruit, two local genera viz. *Argyrea*, *Rivea* (figs. 32, 33) produce berries. The circumsciss e.g. *Operculina turpethum* (fig. 31) or loculicidal e.g. *Merremia* (fig. 30) dehiscence, formation of four e.g. *Merremia tridentata* (fig. 30) or eight (e.g. *Jacquemontia paniculata*) valves, fragile (e.g. *Ipomoea quamoclit*) or thick (e.g. *Rivea hypocrateriformis*) pericarp and glabrous (e.g. *Ipomoea angulata*) or hairy (e.g. *I. hispida*) surface of the capsule can be effectively employed as marks of identification.

5. Solanaceae: The fruit has been used with advantage in the identification of members of the Solanaceae. According to Hassler (1917), the type of fruit is the main criterion for separating the genus *Lycianthes* Hassl. from *Solanum* Linn. (see Santapau, 1948). Species of *Datura* have been distinguished on the basis of fruit characters (see Santapau, l.c.). The possession of capsule (e.g., *Petunia*) or berry e.g. *Withania* (fig. 36), type of fruit, presence of an enveloping calyx e.g. *Withania* (fig. 36), drooping (e.g. *Datura innoxia*) or erect position of the capsule, septicidal (e.g. *Nicotiana*) or septifragal (e.g. *Datura*) dehiscence, unarmed (e.g. *Petunia*), warty e.g. *Datura metel* (fig. 35) or spiny e.g. *D. innoxia* (fig. 34) nature of fruit-wall and colour

of the berries, e.g. yellow (e.g. *Solanum xanthocarpum*), black (e.g. *S. nigrum*), or red e.g. *Withania somnifera*), provide useful key characters.

6. Scrophulariaceae: The fruit is fairly uniform in Scrophulariaceae and affords few characters for distinction of genera and species. Dehiscence of capsule, loculicidal e.g. *Striga euphrasioides* (fig. 38), septicidal e.g. *Verbascum chinense* (fig. 39), or porous e.g. *Kickxia ramosissima* (fig. 41) and the winged e.g. *Lindernia crustacea* (fig. 40) or non-winged (e.g. *Verbascum chinense*) form of the placentiferous column are reliable key characters for genera of this family.

7. Orobanchaceae: *Orobanche cernua* is the only local member of this family. The leathery pericarp of the ellipsoid capsule splits into two (fig. 42) to three or rarely four valves.

8. Lentibulariaceae: In *Utricularia stellaris* (fig. 44) and *U. flexuosa* the capsule is circumsciss, while in *U. caerulea* (fig. 43) it opens by slit-formation.

9. Bignoniaceae: The most prevalent fruit is the capsule (e.g. *Dolichandrone*). In *Kigelia pinnata* there is a large, gourd-like berry (fig. 45). The fruits are many-seeded. In *Doxantha unguis-cati*, the capsule dehiscence near the septum forming two valves and leaving in the centre placentiferous septum which sooner or later separates from portions of the capsule wall to which it was attached (fig. 47).

Genera of this family may be distinguished on the basis of type of fruit, capsule or berry. Form of the flattened capsule: straight e.g. *Tecoma stans* (fig. 46), or falcate e.g. *Dolichandrone falcata* (fig. 48); and dehiscence: loculicidal e.g. *Tecoma stans* (fig. 46); or septicidal e.g. *Dolichandrone falcata* (fig. 48).

10. Pedaliaceae: The oblong capsule in *Sesamum indicum* has scabrid pubescence and shows loculicidal dehiscence (fig. 49).

11. Martyniaceae: This family is represented solely by *Martynia annua*. The exocarp is thick and glandular hairy (fig. 50), peeling off irregularly as the fruit matures. The endocarp is crustaceous, variously sculptured and spiny with two sharp curved apical hooks and a central channel opening between them (fig. 51).

12. Acanthaceae: The loculicidal capsule shows "remarkable mechanism for the dispersion of the seeds" (Rendle, 1938). It is typically two-chambered and dehiscence elastically to eject seeds that are usually situated on hard retinacula (fig. 52). In *Rungia* (fig. 54) and *Dicliptera* the placentiferous apparatus separates elastically from the valves. Absence of well developed retinacula serves to distinguish the sub-families Thunbergioideae and Nelsonioideae.

The number of seeds in the capsule has been employed in distinguishing certain species of *Hygrophila*, *Hemigraphis* and *Barleria* (see Cooke, 1906; Santapau, 1953).

Shape of the capsule (e.g., cylindric in *Ruellia tuberosa*, clavate in *Dipteracanthus prostratus*), its apex (e.g., beaked in *Barleria prionitis*, knobbed in

Dyschoriste erecta), surface (e.g., glandular-hairy in *Andrographis echinoides*, glabrous in *A. paniculata*) and stipitate (e.g., *Justicia quinqueangularis*) or sessile nature also provide useful features for characterising genera and species of this family.

13. Verbenaceae: Genera of this family may be distinguished on the basis of several fruit-characters. Drupes of some genera (fig. 56) have one "stone" which may be four- (e.g. *Premna herbacea*, *Tectona grandis*) or two- (e.g. *Lantana camara*) chambered; others (fig. 57) have four "stones" in their drupes, each "stone" being one- (e.g. *Clerodendrum serratum*) or two- (e.g. *Duranta repens*) seeded.

Fruits of *Stachytarpheta urticifolia* and *Phyla nodiflora* (fig. 58) which split into two one-seeded pyrenes may be classified as schizocarps.

14. Labiatae: The fruit is typically a carcerulus of four nutlets (fig. 59). The number of nutlets may be reduced through abortion e.g. *Hyptis suaveolens* (fig. 60). Their apex may be rounded (e.g. *Salvia plebeia*), obliquely truncate, e.g. *Leucas urticaefolia* (fig. 62) or emarginate e.g., *Hyptis suaveolens* (fig. 61). In *Nepeta hindostana*, the nutlets are blotched (fig. 63). They are glandular at the apex in *Leucas urticaefolia* (fig. 62).

Mukerjee (1940a) distinguishes tribes of the Labiatae on the basis of basal (e.g. *Orthosiphon rubicundus*) or oblique position of the scar and the dry or fleshy character of nutlets. The shape of nutlets and their hairy or winged apex have been employed by him as key characters for genera of this family.

SUMMARY AND CONCLUSIONS

1. The paper presents the results of a carpological study of the Tubiflorae of Nagpur based on the author's personal acquaintance with more than 150 local species belonging to fourteen out of the fifteen Indian plant families of this order.

2. The entire order shows a "syncarpellous, epichlamydous" type of fruit. Another common feature is the presence of persistent calyx which has a diagnostic form in some species.

3. Drupe, berry, capsule and schizocarp are the four principal types of fruit met with in the Tubiflorae. Based on fruit-types, nine families may be broadly classed as "monocarpic", and the remaining five as "bicarpic".

4. Distribution of these fruit-types in the order offers no clue to the relative antiquity of any particular type of fruit. Similarly, while a broad correlation may be seen between fruit-type and habit, exceptions are not wanting.

5. Fruit characters which may be profitably employed in a taxonomic treatment of the Tubiflorae may be enumerated as follows:

- i. *Type*—Berry, drupe, capsule, schizocarp.
- ii. *Shape*—Globose, cylindric, clavate, linear, beaked, falcate.
- iii. *Pericarp*—Thin and membranous, glabrous, pubescent, hairy, spinous, fleshy, woody.

- iv. *Number of chambers*—1, 2, 3, 4, 8.
- v. *Dehiscence*—Circumsciss, loculicidal, septicidal, septifragal, porous, irregular.
- vi. *Number of seeds*—2, 4, 6, 8, many.
- vii. *Arrangement of seeds*—Uniseriate, biseriate, multiseriate.
- viii. *Relative lengths of calyx and fruit*.
- ix. *Other features*—Retinaculate, stipitate, knobbed, etc.

6. This study of fruits also brings forth some inadequacies of the existing system of classification of fruits. *Argyreia* and *Rivea* have "berries", but whereas in the former the fruit is indehiscent, in the latter it shows a circumsciss or irregular dehiscence. The fruit of *Martynia annua* has to be termed a "drupaceous capsule". The so-called "drupes" in *Heliotropium*, *Coldenia*, *Phyla* and *Stachytarpheta* are hardly fleshy and show a pronounced schizocarpic tendency to split into one-seeded mericarps. The capsule of *Operculina* shows a differentiation of pericarp into exocarp and endocarp. Thus the "basic weakness of these classifications is their artificiality and . . . the definitions of their categories or types invariably are violated by abundance of exceptions" (Lawrence, l.c.). But in absence of a more satisfactory classification, the author has been obliged to employ the current conventional terms.

7. There has existed difference of opinion about taxonomy of the Tubiflorae as envisaged by Engler and Diels (l.c.). While some botanists (e.g. Rendle, l.c.) accept them as a single order, others, like Hutchinson (1959), would split them into a number of separate orders. Even among the former, opinion is divided on the families to be included in the Tubiflorae. The existence throughout the taxon of a fundamentally uniform fruit-type ("syncarpellous, epichlamydous") adds weight to the view that "the Tubiflorae form a natural group" (Rendle, l.c.). The study of the distribution of fruit-types and variety of fruit characters in this taxon should, on the one hand, support the grouping of all families into one order and, on the other, bring out several lines of specialisation within this large group. The constituent families need not necessarily "appear to represent several more or less unrelated orders" (Lawrence, l.c.); they may be considered as smaller taxa which, to use the words of Hutchinson (l.c.), "are bound together by a combination of characters and which allow the association of the general tendencies" of development.

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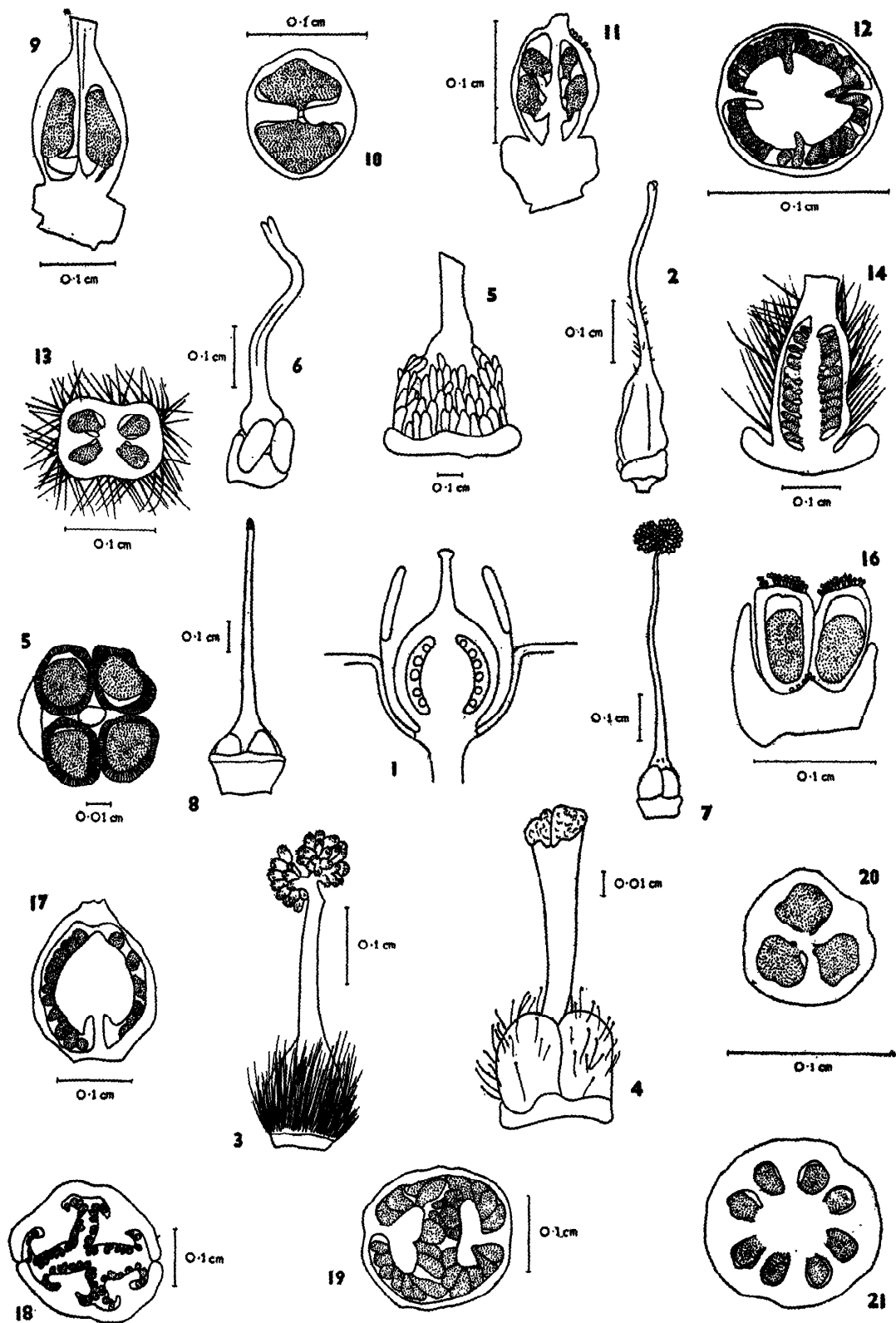
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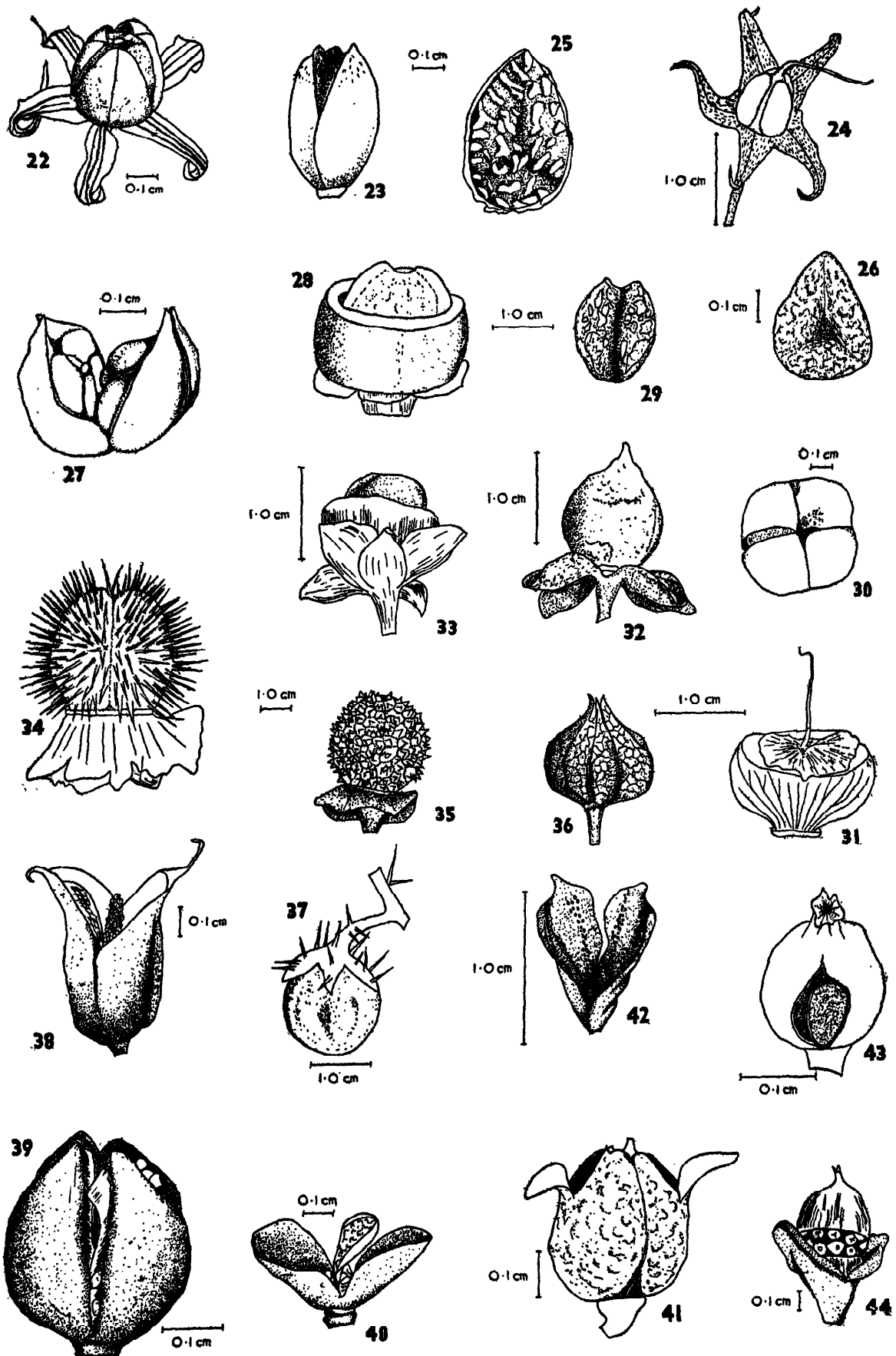
TUBIFLORAE

Ovary (Superior, syncarpous)					Fruit (Syncarpellous, epichlamydous)	Examples
Number of carpels	No. of loculi	Placentation	No. of ovules per loculus	No. of series of ovules per loculus		
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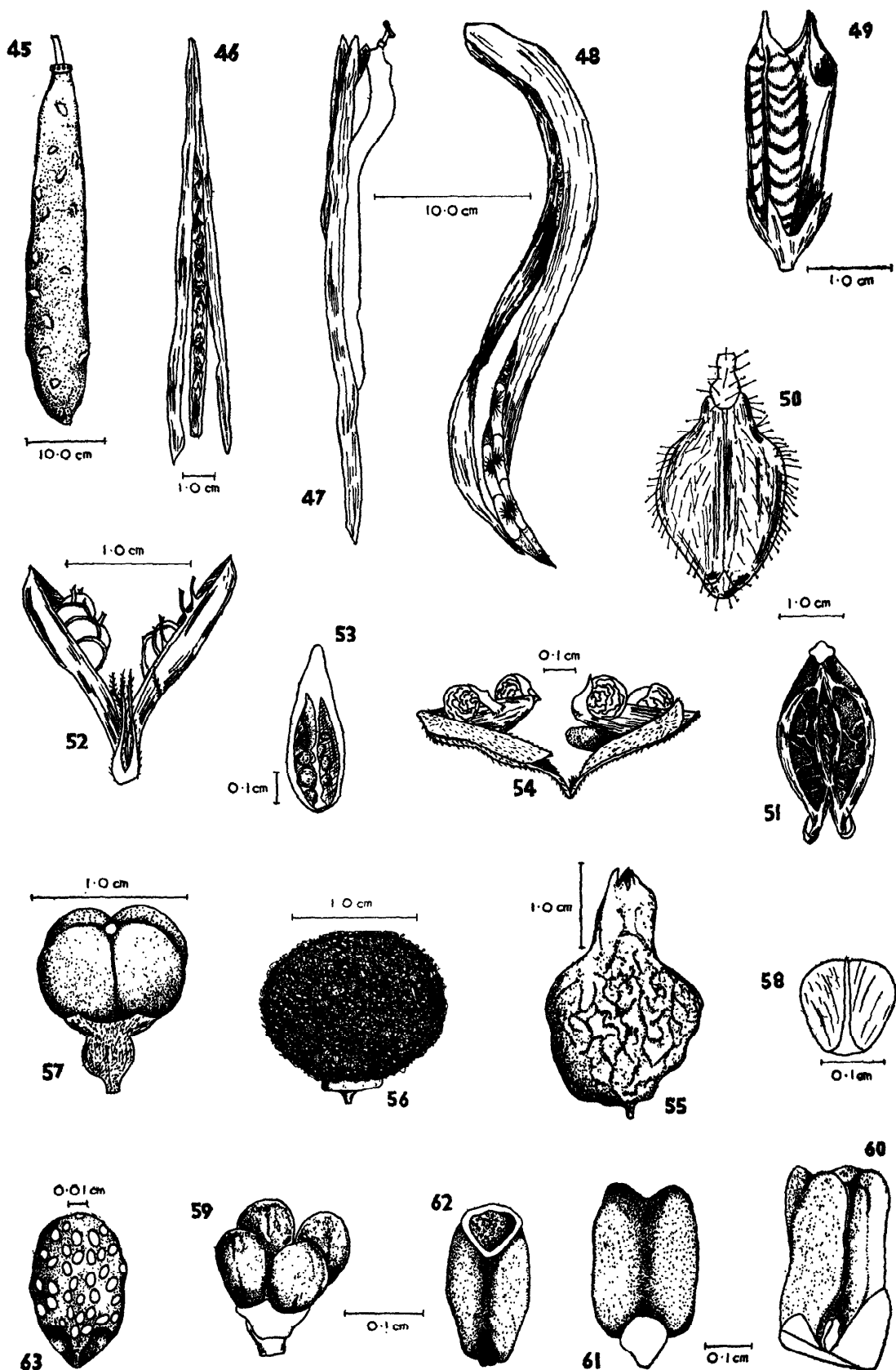
Table showing correlation between the gynaecium and fruit types in the Tubiflorae of Nagpur.



Figs. 1-21. *Tubiflorae*: Gynoecium. 1. Winkler's syncarpellous, epichlamydous fruit type. 2. Ovary stipitate (*Justicia quinqueangularis*). 3. Ovary hairy (*Ipomoea hispida*). 4. Ovary glandular hairy (*Veronica anagallis*). 5. Ovary spiny (*Datura metel*). 6. Style gynobasic (*Hyptis suaveolens*). 7. Style terminal (*Merremia tridentata*). 8. Style subterminal (*Trichodesma zeylanicum*). 9-10. *Blepharis maderaspatensis*: 9. Ovary, l.s. 10. same, t.s. 11. *Andrographis echinoides*: ovary, l.s. 12. *Scoparia dulcis*: ovary, t.s. 13-14. *Sesamum indicum*: 13. Ovary, t.s. 14. Same, l.s. 15-16. *Leucas urticifolia*: 15. Ovary, t.s. 16. Same, l.s. 17. *Utricularia caerulea*: ovary l.s. 18. *Orobancha cernua*: ovary, t.s. 19. *Dopatrium junceum*: ovary, t.s. 20. *Phlox drummondii*: ovary, t.s. 21. *Duranta repens*: ovary, t.s.



Figs. 22-44 *Tubiflorae* : Fruits. 22. Polemoniaceae (*Phlox drummondii*) capsule, loculicidal. 23. Hydrophyllaceae (*Hydrocolea zeylanica*) capsule, septicidal. 24-25. Boraginaceae : 24-25. *Trichodesma indicum*. 24. Schizocarp. 25. Nutlet, inner face. 26. *Trichodesma zeylanicum* nutlet, inner face. 27. *Heliotropium indicum* schizocarp. 28-29. *Cordia dichotoma* : 28. Drupe, cut open to expose the "stone". 29. "Stone". 30. *Merremia tridentata* capsule, four-valved. 31. *Operculina turpethum* capsule, exocarp circumsciss. 32-33. *Rivea hypocrateriformis* : 32. Berry. 33. Same, circumsciss. 34-37. Solanaceae : 34. *Datura innoxia* capsule, spinous. 35. *Datura metel* capsule, warty. 36. *Withania somnifera* berry enveloped in accrescent calyx. 37. *Solanum xanthocarpum* berry with spinous calyx. 38-41. Scrophulariaceae : 38. *Striga euphrasiodes* capsule, loculicidal. 39. *Verbascum chinense* capsule, septicidal. 40. *Lindernia crustacea* capsule, septicidal, placental column winged. 41. *Kickxia ramosissima* capsule, porous. 42. Orobanchaceae (*Orobancha cernua*) capsule, two-valved. 43-44. Lentibulariaceae : 43. *Utricularia caerulea* capsule, dehiscence by slit. 44. *Utricularia stellaris* capsule, circumsciss.



Figs. 45-63. *Tubiflorae* : Fruits. 45-48. *Bignoniaceae* : 45. *Kigelia pinnata* berry. 46. *Tecoma stans* capsule, loculicidal. 47. *Bignonia unguis-cati* capsule, dehiscent. 48. *Dolichandrone falcata* falcate capsule, septicidal. 49. *Pedaliaceae* (*Sesamum indicum*) capsule. 50-51. *Martyniaceae* (*Martynia annua*) : 50. Drupaceous capsule, front view. 51. Endocarp, front view. 52-54. *Acanthaceae* : 52. *Dipteracanthus prostratus* capsule, loculicidal, retinaculate. 53. *Elytraria acaulis* one valve of loculicidal capsule, seeds on papillae. 54. *Rungia elegans* capsule, loculicidal, placentiferous apparatus separating. 55-58. *Verbenaceae* : 55-56. *Tectona grandis* : 55. Drupe enveloped in accrescent calyx. 56. Drupe, pericarp tomentose. 57. *Clerodendrum serratum* drupe. 58. *Phylla nodiflora* schizocarp. 59-63. *Labiatae* : 59. *Salvia plebeia* carcerulus, nutlets four. 60-61. *Hyptis suaveolens*. 60. Carcerulus, nutlets two mature, two abortive. 61. Nutlet, emarginate. 62. *Leucas urticaefolia* nutlet, apex obliquely truncate. 63. *Nepeta hindostana* nutlet, blotched.

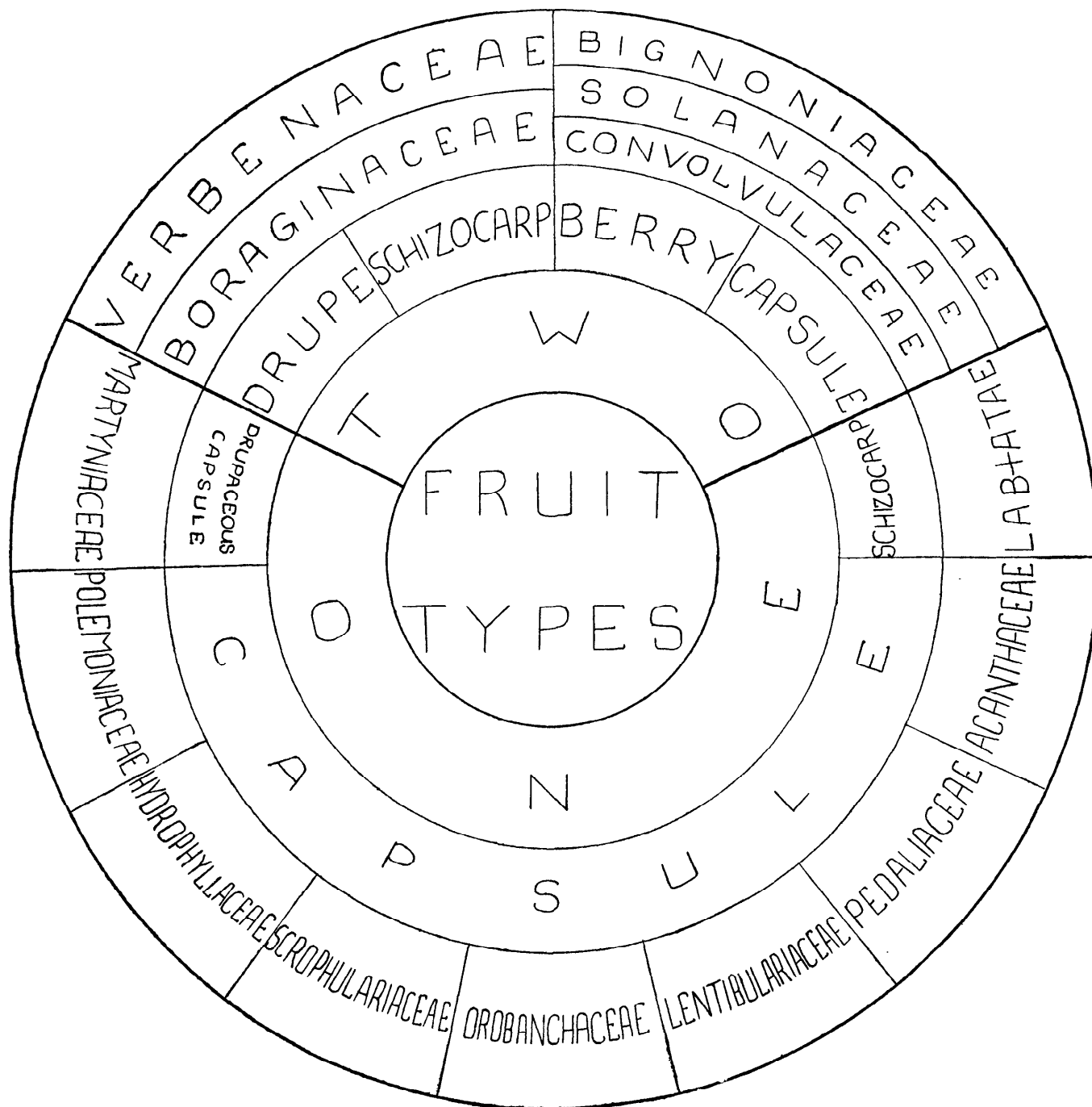


Chart showing distribution of fruit types in the Tubiflorae of Nagpur.