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CONTENTS

A simple Scheme for Identification of common Families of Angiosperms.

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As a result of experience in the practical class, I have seen that students are unable to identify common families of the flowering plants in their course. I have attempted here to give a very simple and useful key for the convenience as well as correct identification of common families of flowering plants. This scheme is formulated with the main purpose of its practical utility rather than enunciating any new approach to the classification, although my ideas are derived from the well known works of Bentham and Hooker, Engler, Hutchinson etc. A graphic representation of the scheme is given here in the form of simplified charts so that a student can come to the preliminary identification by his observation of the fundamental characters used in this scheme. The details of the individual families can be later worked out by subjecting the flowers to a closer examination.

The description of the individual families that follows this graphic scheme, is enough to give a student sufficient information for his further study after he has first understood the fundamentals from the ground plan of this scheme.

The flowering plants namely Angiosperms are classified into two classes, the Dicotyledons and the Monocotyledons. The former possesses reticulate venation in their leaves and generally have tetra or pentamerous flowers whereas the latter are characterised by parallel veined leaves and generally having trimerous flowers. Engler and Hutchinson have further divided the class of dicotyledons into two sub-classes, the Archichlamydeae and the Matachlamydeae or the Sympetalae on the basis of free or united nature of the inner whorl of the perianth respectively.

The sub-class Archichlamydeae can be conveniently divided into two parts, the one having hermaphrodite flowers and the other with unisexual flowers. The part one with hermaphrodite flowers is further differentiated into three sections on the basis of the number and free or united nature of the carpels ; namely section A with apocarpous gynoecium ; Section B with monocarpous gynoecium and Section C with syncarpous gynoecium. The latter in turn can be easily differentiated into two groups: Group (a) with superior ovary and group (b) with inferior ovary. Further, the group (a) may be divided into three sub-groups on the basis of placentation namely, parietal, free central and axile.

ANGIOSPERMS.

- Class : Dicotyledons.
  - Sub class : Archichlamydeae
    - Part 1. Hermaphrodite flowers.
      - Section A. Apocarpous Gynoecium
      - Section B. Monocarpous Gynoecium
      - Section C. Syncarpous Gynoecium.
        - Group A. Superior Ovary.
          - Sub-group 1. Parietal Placentation.
          - Sub-group 2. Free central Placentation.
          - Sub-group 3. Axile Placentation.
        - Group B. Inferior Ovary.
    - Part 2. Unisexual flowers.
      - Section A. Superior 'G'.
      - Section B. Inferior 'G'.
  - Sub class : Metachlamydeae.
- Class : Monocotyledons.

The section A with apocarpous gynoecium possesses under its fold number of families such as the Ranunculaceae, Anonaceae and the Rosaceae which are distinguished on the basis of the number of floral parts in a whorl : trimerous in the Anonaceae and the tetra to pentamerous in the Ranunculaceae and the Rosaceae. The latter two are differentiated from one another by the possession of hypogynous flowers in the former and epi or perigynous flowers in the latter. Some of the important families of this section A, may now be briefly described here.

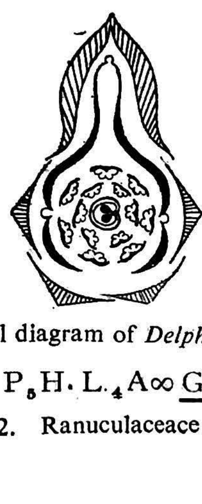
Anonaceae:—Plants: woody shrubs or climbers; leaves: simple, exstipulate, alternate distichous, and gland-dotted ; flowers: trimerous, green or pale yellow, with indefinite stamens and carpels, the latter on centrally raised torus ; fruit: an etaerio of berries.

No. 1 Floral diagram of *Artabotrys odoratissimus*

$$\oplus ⚥\ P_3 + {}_3 + {}_3 A\infty \underline{G}\infty$$

1. Anonaceae

Ranunculaceae:—Plants: predominantly herbaceous; leaves: simple, pinnatisect or pinnately compound with sheathing base; flowers: with indefinite stamens, three to indefinite carpels rarely one *(Delphinium ajacis)* ; fruit: an etaerio of achenes or follicles.

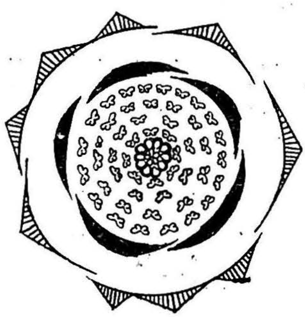


No. 2 Floral diagram of *Delphinium ajacis*

$$\cdot|\cdot\ ⚥\ P_5 H.\ L._4 A\infty \underline{G}\infty$$

2. Ranuculaceace

Rosaceae:—Plants: generally woody, rarely herbaceous, leaves simple or compound without sheathing base ; flowers: with innumerable stamens on the rim of the receptacular cup, five to many carpels, one in Prunoideae *(Prunus)* and Chrysobalanoideae *(Chrysobalanus, Hirtella* and *Parinarium)*; Fruit : etaerio of achenes or drupes.



No. 3 Floral diagram of *Rosa tomentosa* (from Strasburger)

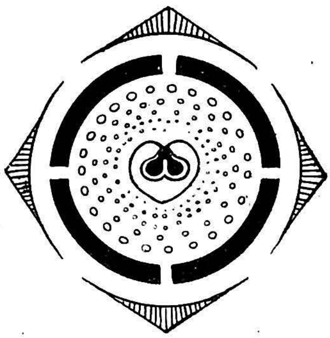
$$\oplus ⚥ \ K_5 C_5 A\infty \tfrac{1}{2}\overline{G}\infty$$

3. Rosaceae

Similarly the Section B. is characterised by monocarpous gynoecium and the families comprising it possess either superior gynoecium as in some Ranunculaceae and the Leguminoseae or half inferior gynoecium (perigynous) as in some of the Rosaceae. The indetification of these families having monocarpous gynoecium is made on the basis of their fruits. The Ranunculaceae possess follicular type of fruit while the Leguminosae are well known for their leguminous fruits. The monocarpous Rosaceae possess only drupes as against etaerio of drupes present in apocarpous Rosaceae described in Section A.

The family Leguminoseae is one of the largest families among the dicotyledons and exhibits a wide range in its habit, symmetry and structure of the flower so much so that it has been divided into three sub families : Mimosoideae, Caesalpinoideae and Papilionatae. These are distinguished from each other by their characteristic corolla and androecium as below:—

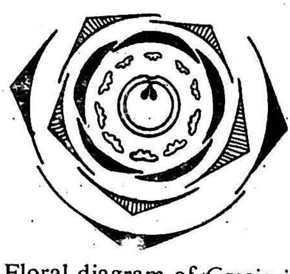
	Mimosoideae	Caesalpinoideae	Papilionatae.
Corolla	Rosaceous, Regular, Valvate.	Rosaceous, Irregular, Ascending imbricate.	Papilionaceous, Irregular, Vexillary.
Stamens	Indefinite.	Ten, including staminodes when present, inserted or exerted.	Ten, monadelphous or diadelphous, inserted and enclosed by Keel petals.



No. 4 Floral diagram of *Acacia latifolia* (after Eichler)

$\oplus$ ⚥ $K_4 C_4 A\infty \frac{1}{2} \overline{G}_1$

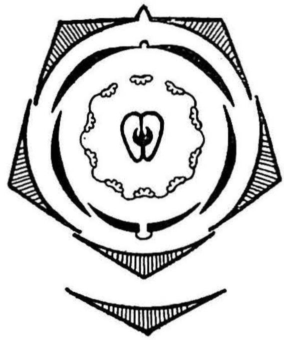
4. Mimosoideae



No. 5 Floral diagram of *Cassia javanica*

$\cdot|\cdot$ ⚥ $K_5 C_5 A_{10} \frac{1}{2} \overline{G}_1$

5. Caesalpionoideae



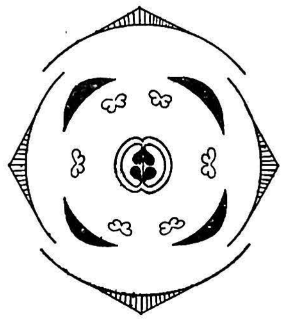
No. 6 Floral diagram of *Vicia Faba* (after Eichler)

$\cdot|\cdot$ ⚥ $K_5 C_5 A_{10\frac{1}{2}} \underline{G}_1$

6. Papilionatae

The families in the section C possess a syncarpous gynoecium. The latter may be inferior or superior. The families with superior gynoecium are easily differentiated from one another on their placentation and hence have been divided into three sub-groups in this classification. The sub-group one with parietal placentation consists of families showing two important features, firstly the presence of replum connecting the two parietal placentae giving rise to a bilocular condition of the carpels as in the Cruciferae and secondly the presence or absence of placental outgrowths not uniting as in the first thus maintaining a monolocular condition represented by the Capparidaceae and Papaveraceae. The latter two families are distinguished from each other by the presence or absence of a gynophore. The sub-group two with free central placentation easily distinguishes the family Caryophyllaceae from others. The sub-group three with axile placentation comprises families which possess either monothecous anthers as in Malvaceae or dithecous anthers as in Tiliaceae and Rutaceae. The latter two families differ from each other by the presence of an intrastaminal disc in Rutaceae and the absence of the same in Tiliaceae.

Cruciferae:—Plants herbaceous, annual or perennial ; leaves : simple or lyrate, alternate, exstipulate, and cauline or radical ; lower: tetramerous, Corolla cruciform ; stamens tetradynamous, gynoecium bicarpellary, syncarpous, bilocular with parietal placentation ; fruit : silliqua or silicula with replum.

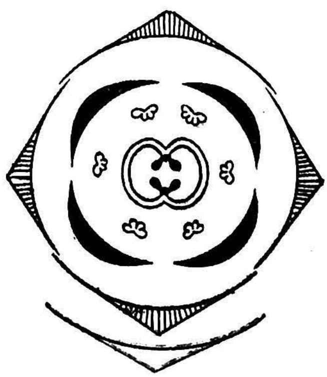


No. 7 Floral diagram of *Brassica nigra*

$\oplus$ ⚥ $K_4 C_4 A_{4+2} \underline{G}_{(2)}$

7. Cruciferae

Capparidaceae:—Plants: woody ; leaves : simple or palmately compound with or without stipules, alternate ; flower : tetramerous, 4-6 or indefinite stamens of equal length on the receptacle or androphore, 2-4 or more carpellary syncarpous, monolocular gynoecium on a gynophore, parietal placentation ; fruit : a berry or siliqua without replum.

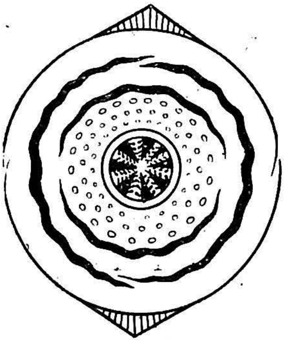


No. 8 Floral diagram of *Gynandropsis pentaphylla*

$\oplus$ ⚥ $K_4 C_4 A_6 \underline{G}_{(2)}$

8. Capparidaceae

Papaveraceae:—Plants: herbaceous with or without latex; leaves: simple or lobed or divided, exstipulate, alternate ; flowers : dimerous, or trimerons 2-4 or indefinite stamens of equal length on the receptacle, 2 or more carpellary syncarpous, monolocular gynoecium without gynophore, parietal placentation; fruit: poricidal or septicidal capsule, rarely a nut.

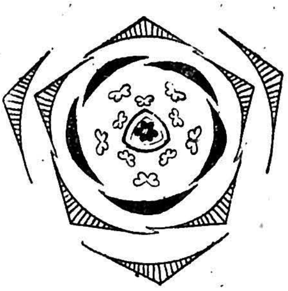


No. 9 Floral diagram of *Papaver rhoeas*

$\oplus$ ⚥ $K_2 C_{2+2} A_\infty \underline{G}_{(\infty)}$

9. Papaveraceae

Caryophyllaceae:—Plants: mostly herbaceous ; leaves : simple, exstipulate, opposite on swollen nodes ; flowers : pentamerous aggregated in cymose cluster ; corolla Caryophyllaceous ; androecium obdiplostemonous ; gynoecium 2-5 carpellary syncarpous, free central placentation throughout or free central above and axile below ; fruit : a capsule.



No. 10 Floral diagram of *Silene inflata* (after Eichler)

$\oplus$ ⚥ $K_{(5)} C_5 A_{5+5} \underline{G}_{(8)}$

10. Caryophyllaceae

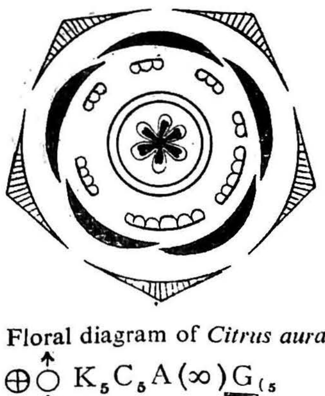
Malvacae:—Plants: herbaceous or woody ; leaves : simple or palmately lobed, stipulate alternate, devoid of gland dots ; flowers : pentamerous, epicalyx present with the exception of *Sida* and *Abutilon ;* corolla twisted ; stamens indefinite, monadelphous, forming a tube, anthers reniform and versatile ; gynoecium 5 or more carpellary syncarpous, free at the tip of the style with individual stigma ; fruit: cspuale or carcerulus.

No. 12 Floral diagram of *Gossypium herbaceum*

$\oplus$ ⚥ $Ep_3 K_{(5)} C_5 A(\infty) \underline{G}_{(3)}$

12. Malvacae

Rutaceae:—Plants: woody; leaves: pinnately or unifoliately compound, exstipulate, alternate, gland dotted ; flowers : pentamerous, stamens obdiplostemonous or polyadelphous, intrastaminal disc, gynoecium syncarpous throughout or in style and stigma; fruit : berry or hesperidium.

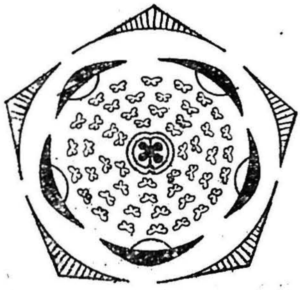


No. 13 Floral diagram of *Citrus aurantium*

$\oplus$ ⚥ $K_5 C_5 A(\infty) \underline{G}_{(5}$

13. Rutaceae

Tiliaceae:—Plants: herbaceous or woody, leaves : simple or occasionally lobed, stipulate, alternate, not gland dotted ; flowers : pentamerous, corolla imbricate, glandular at the base, stamens indefinite, free or polyadelphous, gynoecium, syncarpous, free at the tip of the style with distinct stigmas ; fruit : capsule or drupe.



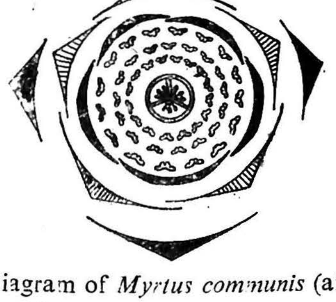
No. 11 Floral diagram of *Grewia asiatica*

$\oplus$ ⚥ $K_5 C_5 A \infty \underline{G}_{(2)}$

11. Tiliaceae

The families of the section C possessing the inferior gynoecium may have indefinite number of stamens as in Myrtaceae or have only ten or five stamens as in Combretaceae and Umbelliferae. In between the latter two families the Combretaceae have monolocular ovary with pendulous ovules while the Umbelliferae possess bilocular ovary with one ovule in each locule on axile placentation.

Myrtaceae:—Plants :woody ; leaves : simple, exstipulate with intramarginal vein, alternate, gland dotted ; flowers : tetra to pentamerous, calyx persistent, corolla caducous, stamens indefinite and incurved on the rim of the receptacular cup, anthers versatile, single style with simple or capitate stigma ; fruit : berry or capsule.

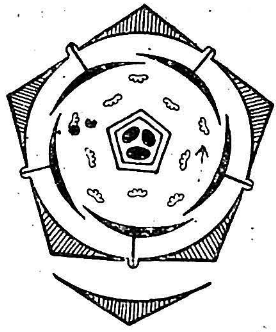


No. 14 Floral diagram of *Myrtus communis* (after Eichler)

$\oplus$ ⚥ $K_5 C_5 A \infty \overline{G}_{(3)}$

14. Myrtaceae

Combretaceae:—Plants: woody arborescent or climbers; leaves : simple, exstipulate, alternate or opposite; flowers: tetra to pentamerous, calyx tubular bearing the petals and stamens, stamens ten to four incurved, anthers versatile, style single with simple stigma ; fruit : one seeded, indehiscent with angles or wings.

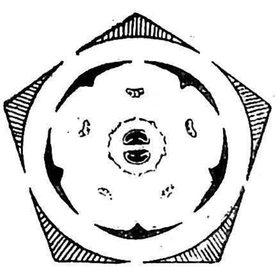


No. 15 Floral diagram of *Quisqualis indica*

$\oplus ⚥\ K_{(5)}\ C_5 A_{5+5}\ \overline{G}_1$

15. Combretaceae

Umbelliferae:—Plants: herbaceous with fistular internodes and ridged stem ; leaves : pinnately divided rarely simple, alternate, exstipulate with sheathing base, essential oil present ; flowers : pentamerous arranged in umbel type of inflorescence, stamens, five incurved, anthers basifixed or dorsifixed, styles free, two with simple stigma and bulbous stylopodium at the base ; fruit: cremocarp with two mericarps.



No. 16 Floral diagram of *Coriandrum sativum*

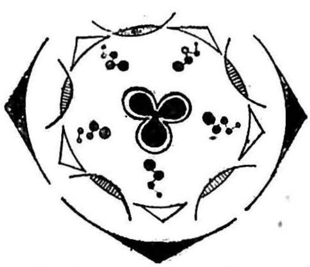
$\oplus ⚥\ K_5 C_5 A_5 \overline{G}_{(2)}$

16. Umbelliferae

The part 2 consists of families bearing unisexual flowers. They may be also divided as in part one into two sections, section A with families having superior gynoecium and section B with inferior gynoecium. Those which possess only superior gynoecium are considered here because families with inferior gynoecium such as Fagaceae, Betulaceae etc. are not prescribed for elementary studies. Further differentiation of these families with superior gynoecium is based on the number of locules and ovules in an ovary. The family Moraceae consists of monolocular ovary with one basal ovule while family Euphorbiaceae consists of trilocular ovary with one pendulous ovule in each locule on axile placentation.

Moraceae:—Plants: predominantly woody with latex; leaves: simple with intrapetiolar or lateral stipules, alternate; flowers: apetalous arranged in hypanthodium (e.g. *Ficus*) or Catkin (e.g. *Morus*), stamens anteposed (opposite to the perianth lobes), gynoecium with simple or bifid style; fruit: simple achenes, drupes or multiple type (Syconus or Sorosis).

Euphorbiaceae:—Plants: varying from herbaceous to woody arborescent with latex, leaves: simple, lobed or deeply cut or palmately compound, may be stipulate; alternate; flowers: apetalous with the exception of male flowers of *Jatropha* and *Croton*, or achlamydeous as in *Euphorbia*, arranged in catkin or cyathium; stamens one to indefinite, may be branched as in *Ricinus*, gynoecium tricarpellary, syncarpous, trilocular with three styles, free or united at the base; fruit: regma type of schizocarp.



No. 18 Floral diagram of *Cyathium inflorescence*

The sub-class Metachlamydeae or Sympetalae can also be broadly classified into two parts, part one with bisexual flowers and part two having unisexual flowers. The part one is divided into two sections, A and B : section A with superior gynoecium and section B with inferior gynoecium. The section A can be further differentiated into two groups : the group (a) consisting of regular flowers and the group (b) consisting of irregular flowers. The group (a) however, comprises two subgroups, one with twisted the other with induplicate valvate or imbricate aestivation. The part two is represented by the family Cucurbitaceae and some members of the Compositiae. This classification is given below:—

METACHLAMYDEAE

Part 1. Bisexual Flowers. | Part 2. Unisexual flowers

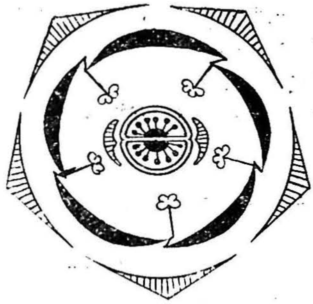
Section A. Superior gynoecium | Section B. Inferior gynoecium.

Group (a). Regular flower. | Group (b). Irregular flower.

Sub-group 1. Twitsted aestivation. | **Sub-group 2.** Induplicate valvate or imbricate aestivation.

The subgroup 1. consists of families which are differentiated on the presence of a translator as in Asclepiadaceae or absence of a translator as in Apocynaceae. The translator is a pollen tranfer-ring structure.

Apocynaceae:—Plants: varying from herbs, shrubs to trees including woody climbers with latex ; leaves : simple, opposite decussate rarely alternate or whorled generally exstipulate; flowers: pentamerous, twisted corolla with corolline corona, stamens five, epipetalous at the throat of the corolla very near the stigma, anthers adnate with loose pollen, no translator ; gynoecium bicarpellary, united either throughout or only by the style and stigma, stigma rattle or dumbell shaped ; fruit: a pair of follicles or drupe.

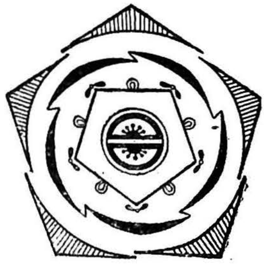


Nh. 19 Floral diagram of *Vinca rosea*

$\oplus$ ⚥ $K_5 C_{(5)} A_5 \underline{G}_{(}$

19. Apocynaceae

Asclepiadaceae:—Plants: woody herbs or shrubs, often climbing, latex present ; leaves: simple, opposite, decussate, exstipulate; flowers: petamerous, corolla twisted, stamens five, epipetalous, filaments united to form a fleshy hollow column with the glandular corona at the back, anthers united with the pentangular stigma to form gynostegium, pollen united into a waxy mass called pollinium, translator spoon or Y-shaped ; gynoecium bicarpellary united only by the stigma ; fruit: a pair of follicles.



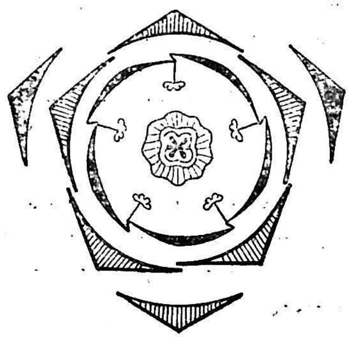
No. 20 Floral diagram of *Calotropis procera*

$\oplus$ ⚥ $K_5 C_{(5)} A_5 \underline{G}_{(2)}$

20. Asclepiadaceae

The families of the subgroup 2. differ among themselves either in having the two carpels medianly placed as seen in Convolvulaceae and Boraginaceae, or in having the carpels obliquely placed as in Solanaceae. The former two families are diagnosed by the type of inflorescenee which is characteristically scorpioid cyme in Boraginaceae, while it is not so in Convolvulaceae.

Convolvulaceae:—Plants: herbaceous or woody climbers, some parasites; leaves: simple entire or lobed, exstipulate alternate; flowers: pentamerous, sepals unequal in size, quincuncial persistent, petals plicate, twisted ; stamens five, epipetalous unequal in length, anthers sagitate dorsifixed; ovary tetralocularwith one ovule in each locule on axile placentation at the base ; fruit : capsule or berry.

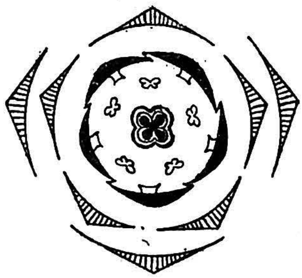


No. 21 Floral diagram of *Ipomea palmata*

$$\oplus \; ⚥ \; K_5 \, \overbrace{C_{(5)} \; A_5} \; \underline{G}_{(2)}$$

21. Convolvulaceae

Boraginaceae:—Plants: varying from herbaceous to arborescent trees ; leaves : simple, exstipulate, rarely opposite ; flowers : pentamerous, sepals equal in size persistent, corolla imbricate rarely twisted; scales below the five epipetalous stamens, which are of equal length ; ovary tetralocular with one ovule attached to the apex of the axis in each locule ; fruit : drupe or nutlets.

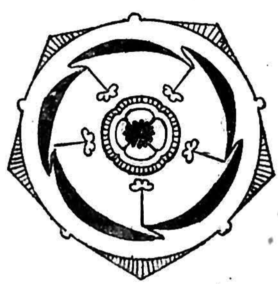


No. 22 Floral diagram of *Anchusa* (after Eichar)

$\oplus$ ⚥ $K_5 \, \overset{\frown}{C_{(5)} \, A_5} \, \underline{G}_{(2)}$

22. Boraginaceae

Solanaceae:—Plants: herbs, shrubs, rarely trees or climbers ; leaves: simple, exstipulate, opposite, generally adnate with the axillary branch up to the next higher node ; flowers : pentamerous, sepals of equal size united persistent ; corolla plicate and twisted when regular, imbricate when irregular ; stamens five epipetalous, equal in length when the corolla is regular, unequal in length or didynamous when the corolla is irregular as in the tribe Salpiglossideae, anthers free or syngenesious (*Solanum*) ; ovary bilocular rarely tetralocular (*Datura*), indefinite number of ovules on fleshy axile placenta; fruit : capsule or berry.



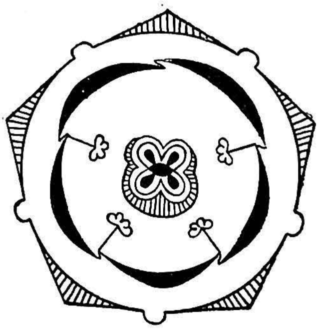
No. 23 Floral diagram of *Datura fastuosa*

$\oplus$ ⚥ $K_{(5)} \, \overset{\frown}{C_{(5)} \, A_5} \, \underline{G}_{(2)}$

23. Solanaceae

The families of group (b) exhibit two main distinguishing features such as the gynobasic style as found in the Labiatae and a terminal style as seen in the Verbenaceae, Scrophulariaceae and Acanthaceae. The latter families are distinguished by the number .of ovules present in each locule of the ovary on axile placentae namely one or two ovules in the Verbenaceae, indefinite in the Scrophulariaceae, and one or two rows of ovules in the Acanthaceae.

Labiatae:—Plants: herbs or shrubs with a quadrangular stem ; leaves: decussate or whorled, exstipulate with glandular hairs containing essential oil ; flowers: pentamerous aggregated into a verticellaster; sepals united, bilabiate and persistent petals bilabiate and imbricate ; stamens four or two, epipetalous, didynamous when four; gynoecium bicarpellary with four lobed locules each containing one ovule, style gynobasic with bifid stigma ; fruit: carcerulus.

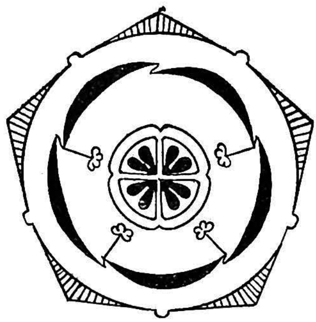


No. 24 Floral diagram of *Ocimum basilicum*

$$\cdot|\cdot \; ⚥ \; K_5 \, \overbrace{C_{(5)} \, A_4} \, \underline{G}_{(2)}$$

24. Labiatae

Verbenaceae:—Plants: herbs, shrubs or trees, some climbers ; leaves: simple, opposite, decussate, exstipulate without glandular hairs; flowers : tetra to pentamerous ; sepals united and persistent, petals imbricate, stamens four rarely five as in *Tectona* ; epipetalous, didynamous ; gynoecium bicarpellary bi or tetralocular, one or two ovules in each locule, style terminal with bifid stigma ; fruit : a drupe.

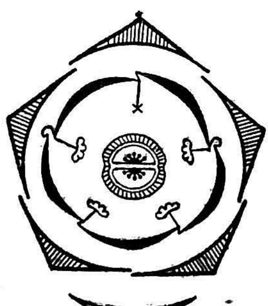


No. 25 Floral diagram of *Duranta plumieri*

·|· ⚥ $K_5 \, \overbrace{C_{(5)} \; A_4} \; \underline{G}_{(2)}$

25. Verbenaceae

Scrophulariaceae:—Plants: herbs, some parastic on roots leaves: simple, entire or dissected, exstipulate, imbricate; stamens four or rarely two or five, epipetalous, didynamous when four, posterior stamen absent ; gynoecium bicarpellary, bilocular, ovules indefinite on thick axile placentation, style terminal with capitate or bilobed stigma ; fruit: a capsule.

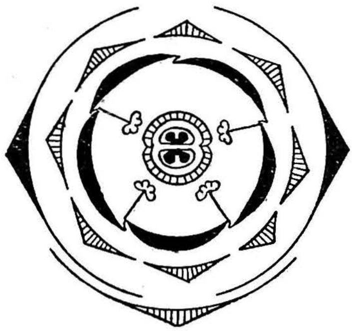


No. 26 Floral diagram of *Russelia juncea*

·|· ⚥ $K_5 \, \overbrace{C_{(5)} \; A_4} \; \underline{G}_{(2)}$

26. Scrophulariaceae

Acanthaceae:—Plants: herbs, shrubs or climbers ; leaves: opposite, decussate, exstipulate ; flowers: pentamerous petals imbricate or twisted ; stamens four or two, epipetalous didynamous when four, anther lobes unequal, bearded ; gynoecium bicarpellary, bilocular with one to two rows of ovules in each locule on axile placentation, style terminal with unequal lobes of stigma; fruit: a capsule with seeds having reti ula or jaculator.



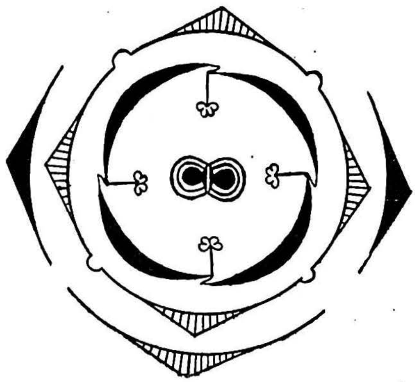
No. 27 Floral diagram of *Thunbergia affinis*

$$\cdot|\cdot\ \text{⚥}\ K\infty \, C_{(5)}\, A_4\, \underline{G}_{(2)}$$

27. Acanthaceae

In section (b) of the metachlamydeae all families possess inferior gynoecium and are distinguished on the type of placentation : axile in the Rubiaceae and basal in the Compositae.

Rubiaceae:—Plants: trees, shrubs, rarely herbs ; leaves: simple, opposite, decussate with interpetiolar stipules ; flowers: tetra to pentamerous, aggregated into a cyme or a head ; calyx reduced in size, valvate ; corolla contorted, stamens isomerous, epipetalous, situated at the throat of the corolla, anthers in close proximity with the stigma ; gynoecium bicarpellary, bilocular with many ovules in each locule, axile placentation, style filiform long with bifid stigma ; fruit: berry or a capsule.

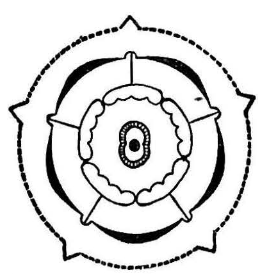


No. 28 Floral diagram of *Ixora coccinea*

$$\oplus\ ⚥\ K_4\ \widehat{C_{(4)}\ A_4}\ \overline{G}_{(2)}$$

28. Rubiaceae

Compositae:—Plants: predominently herbaceous; leaves: simple or pinnately divided, alternate, exstipulate ; flowers: pentamerous aggregated into a capitulum, calyx rudimentary ; corolla tubular or campanulate as in disc florets, or ligulate or bilabiate as in ray florets, valvate ; stamens five, epipetalous ; anthers syngenesious ; gynoecium bicarpellary, monolocular with one basal ovule, style slender with stigma bifid, recurved and hairy ; fruit: an achene. Some Compositae, however, are dioecious in their floral organisation such as *Xanthium* spp. and it is such members that are included under part two of this scheme.

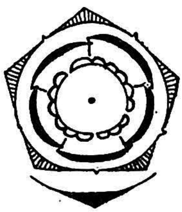


No. 29 Floral diagram of *Compositae* (after Elchler)

$$\oplus\ ⚥\ K_5\ \widehat{C_{(5)}\ A_5}\ \overline{G}_{(2)}$$

29. Compositae

Cucurbitaceae:—Plants: herbs, climbing by tendrils; leaves: simple or lobed, alternate, palminrved, exstipulate, hairy ; flowers: unisexual, pentamerous ; calyx well developed, united, imbricate; corolla campanulate, imbricate or induplicate valvate; stamens in male flower variously united, epipetalous, anthers curved; gynoecium tricarpellary, monolocular with innumerable ovules on parietal placentation, style single with three stigmas; fruit : a pepo, rarely a capsule.



No. 30 (a) *Luffa acutangula*

(b) *Luffa acutangula*

$\oplus$ ♂ $K_{(5)} C_{(5)} A_{2+2+1}$

30. (a) Cucurbitaceae

$\oplus$ ♀ $K_5 C_{(5)} \overline{G}_{(5}$

30. (b) Cucurbitaceae

Among the Metachlamydeae, Cucurbitaceae alone represents part two having unisexual flowers. In fact the systematic position of this family is somewhat debatable.

The monocotyledons can be divided into two parts : part 1, consisting of bisexual flowers, and Part 2, unisexual flowers. Both the parts are further classified into two sections each. Section A with apocarpous ovary and Section B with syncarpous ovary. The latter is differentiated into two groups based on the position of ovary : Group (a) with superior ovary and Group (b) with inferior ovary.

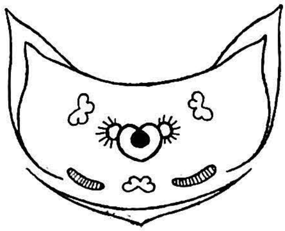
MONOCOTYLEDONS

- Part 1. Bisexual flowers.
  - Section A. Apocarpous gynoecium
  - Section B. Syncarpous gynoecium.
    - Group a. Superior Ovary.
    - Group b. Inferior Ovary.
- Part 2. Unisexual flowers.
  - Section A. Apocarpous gynoecium.
  - Section B. Syncarpous gynoecium.
    - Group a. Superior Ovary.
    - Group b Inferior Ovary.

In this scheme only the section B of both the parts is considered while the section A is omitted as only a few families come under that category and these are not commonly studied by the graduate (B. Sc. Degree) students. Even in section B only common families are considered.

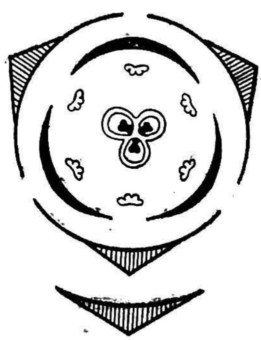
In the section B of the part 1. the families of the group A are characterised by the type of inflorescence : panicle of spikelets consisting of glumes and palea represents Gramineae while simple raceme or rarely solitary or cymose umbel denotes Liliaceae.

Gramineae:—Plants: herbs or woody arborescent with cylindrical jointed and fistular stem ; leaves: simple, alternate, distichous with the split sheath, linear lamina and membranous ligule ; flowers in spikelet with lower involucral glume, upper floral glume and palea, perianth represented either by two scale like lodicules or not ; stamens three, anthers versatile, gynoecium monocarpellary monolocular with one basal ovule, styles two, rarely one or three, stigma hairy; fruit: a caryopsis.



No. 31 Floral diagram of *Gramineae*

Liliaceae:—Plants: herbs with rhizome, corm or bulb, some climbing ; stem sometimes cladode or phylloclade ; leaves: simple, radical or cauline or reduced, alternate, dorsiventral or centric ; flowers : trimerous aggregated into a raceme rarely a cymose umbel or solitary, regular, perianth six in two series, petaloid, stamens six in two series, epiphyllous ; gynoecium tricarpellary, trilocular with indefinite number of ovules in each locule on axile placentation, fruit: a capsule.



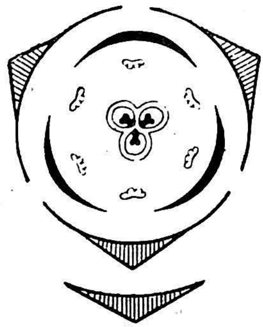
No. 32 Floral diagram of *Asphodelus tenuifolius*

$$\oplus\ ⚥\ P_{3+3}\ A_{3+3}\ \underline{G}_{(3)}$$

32. Liliaceae

The families of the group (b) in the part 1 are differentiated primarily by the symmetry of the flowers ; as regular in Amarylidaceae, irregular in Orchidaceae and secondarily by the number of functional stamens and placentation; all the six stamens functional in Amaryidaceae with indefinite ovules on axile placentation, only one median anterior stamen functioning with number of ovules on parietal placentation in the Orchidaceæ.

Amarylidaceæ:—Plants: herbs or shrubs with bulb or corm ; leaves : simple and radical ; flowers : trimerous, aggregated in umbel or solitary on scape ; perianth six, petaloid, united into a distinct tube ; stamens six, epiphyllous ; gynoecium tricarpellary, trilocular with numerous ovules in each locule on axile placentation, style long, stigma trifid or capitate ; fruit : a capsule.

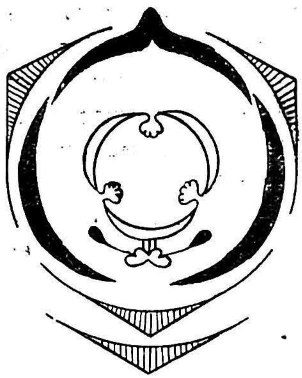


No. 33 Floral diagram of *Zephyranthes rosea*

$$\oplus \text{⚥}\ P_{3+3}\ A_{3+3}\ \overline{G}_{(3)}$$

33. Amarylidaceæ

Orchidaceæ:—Plants: herbs, terrestrial or epiphytic rarely saprophytic with rhizomes or tuberous roots or pseudo-bulbs ; leaves : simple, alternate, distichous, rarely opposite, fleshy, sheathing at the base ; flowers : trimerous aggregated into raceme or spike ; perianth six in two series, outer sepals and inner petals, unequal in size, median one being large to form the labellum, anterior in position due to resupination or twisting; stamen single, rarely two, united with the style to form gynostemium, anther lobes with pollinium which are connected to the rostellum (one of the stigmas projecting out) by thread like structure called caudicle ; gynoecium tricarpellary, monolocular, numerous ovules on parietal placentation ; fruit : a capsule.



No. 34 Floral diagram of *Orchis* (afther Eichler)

$$\cdot|\cdot \overset{\uparrow}{\underset{+}{\bigcirc}} P_{3+3}\ A_1\ \overline{G}_{(3)}$$

34. Orchidaceæ

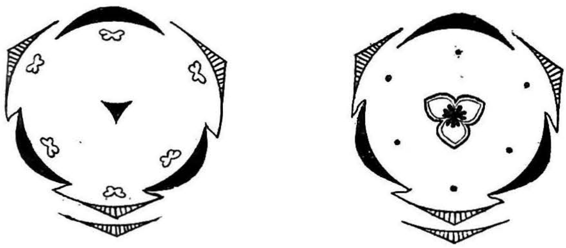
The families of the group a. in part 2. are distinguished by their spadix type of inflorescence. They are further diagnosed either by simple spadix with unbranched axis as found in Araceae or compound spadix with branched axis as found in the Palmae.

Araceæ:—Plants: herbs with corm or tuberous stem, sometimes climbing ; leaves : radical or cauline, simple, alternate, hastate, sagitate or strap-shaped sheathing at the base ; flowers : generally naked, aggregated into simple spikes subtended by a petaloid spathe; stamens varying in number from 2-4-8, opposite to perianth when present ; gynoecium tricarpellary, trilocular rarely monocarpellary and monolocular one to indefinite number of ovules, placentation axile to basal stigma free and sessile, ; fruit : a berry.

Palmæ:—Plants: shrubs, trees or climbers, stem usually unbranched and erect; leaves : palmate or pinnate, alternate, aggregated into a crown at the apex with sheathing base, vernation plicate; flowers: trimerous, perianth six in two whorls, outer as sepals, imbricate, inner as petals, valvate in male, imbricate in female, persistent; stamens six in whorls, rarely three ; gynoecium tricarpellary, trilocular usually, occasionally monolocular, one ovule in each locule at the base, stigma three, sessile ; fruit : a berry or drupe. In *Phoenix* carpels are free as an exception.

The families of the group (b) in part 2 can be diagnosed by the type of inflorescence ; spadix in Musaceæ and raceme or solitary in others.

Musaceæ:—Plants: perennial, rhizomatous herbs with ærial stem formed by the stiff rolling of leaf sheaths one over the other or tree like with woody trunk ; leaves : simple, large, alternate, with strong mid-rib and parallel veins laterally extending to the margin, base sheathing ; flowers : trimerous, free or united, median perianth segment of inner series short ; stamens five, rarely six (e.g. *Ravenala*), posterior stamen as staminode or suppressed ; gynoecium tricarpellary, trilocular with numerous ovules in each locule on axile placentation, style long, stigma lobed ; fruit : a berry.



No. 37 Floral diagrams of *Musa paradisiaca*.

·|· ♂ $P_{(3+3)} A_{5+1}$ std. ·|· ♀ $P_{(3+3)} G_{(3)}$

37 (a) Musaceæ 37 (b) Musaceæ

SUMMARY

As the scheme oulined in tho foregoing pages is already too brief, it is not necessary to repeat the points of usefulness of the scheme. Therefore, the whole idea of classification for the purpose of the students is only repeated in the form of a chart.

I take this opportunity to express my sincere thanks to Dr. K. M, Gupta, Head of the Department of Botany, for his helpful criticism in preparing this scheme.

BIBLIOGRAPHY

1. Hutchinson, J. 1926. "The families of Flowering Plants." Vol. I.
2. Rendle, A. B. 1930 & 1938. "The Classification of Flowering Plants." Vol. & II.
3. Willis, J. C. 1951. "The Dictionary of Flowering Plants and Ferns".

Root Development Of Gynandropsis Pentaphylla DC.

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While working on the :Authecology of *Gynandropsis pentaphylla* DC. some interesting ecological adaptations of the root system were noted. These observations help us to correlate the development of the root system of the plant in terms of its habitat, nature of the soil and the available water supply in the area.

The root system of *Gynandropsis pentaphylla* DC. of a primary tap root which penetrates the substratum upto two and a half feet and then divides either dichotomously or gives out finer branches in all directions, the latter covering a large area. The root system of the plant was worked out in different localities according to the nature of the substratum. The factors controlling the nature of the root system and their relative penetration in the substratum were found to be the amount of annual precipitation, the amount of water available during the growing season, nature and composition of the substratum, texture of the soil, moisture contents of the soil, aeration of the soil and the depth of the water table below the soil surface.

The main roots and their lateral branches were traced in the soil and their lengths were measured. The finer rootlets were traced with the help of a metallic pointer. Plants growing in different soil as well as on the slopes of *N llahs* were selected for this study. It was possible to trace out the finer branches of the roots in such slopes. Mature plants were selected in different localities for the study of the root penetration. In every locality the root system of three mature plants was worked out and the mean was calculated. The diagrams of the root system were drawn to scale.

The plant *Gynandropsis pentaphlla* DC. is well adapted to the sandy localities ; this is shown by the fact that it has a deep tap root system. In sandy substratum the soil is coarse and the rain water which is not abundant percolates into the soil almost immediately after rains. The rate of percolation of water is very high and it becomes very difficult for shallow rooted plants to absorb water, while the plant under investigation can grow well as evidenced by deep root system. In all the sandy localities worked out, the root system was found to be very deep, sometimes the finer rootlets nearly reaching thrice the length of the shoot system. In one case it was noted that the height of the shoot was only one foot two inches while the root system was three feet and one and a half inches long. Generally, a few finer rootlets are given out just below the surface of the soil, so that even small amount of water from a light shower can be absorbed easily. Generally, the tap root branches into rootlets, which penetrate deep into the soil and then give out lateral rootlets in adundance (Fig. 1). The fact can be correlated with the deep water table in the area and easy penetration of the soil due to its coarse texture.

On the other hand the root system in gravel is altogether different. The root system (Fig. 2) of the plants growing in the stones and pebbles (Waste stones along the road side) were worked out as the plants were not present on the hills. The root system in these cases was not so deep as that of those in the sandy substratum, but the branching was much more profuse and dense. The lateral roots were even given out from the base of the root and they generally traversed long distances just below the surface of the substratum instead of directly passing down. The ultimate ramifications were profuse. This type of root system is definitely caused by the texture of the soil, which is very coarse, and by the nature of the substratum which is a mixture of eolian parent material, pebbles and stones of various forms. Profuse development of the root system is due to the scarcity of water and good aeration of the soil.

The root system in the clayey soil also exhibtts peculiar adaptation. Here the roots are less developed than the roots of the plants growing in sandy or gravel area. Again the roots penetrate the substratum only to a lesser extent than in sand or gravel. The length of the roots in this soil ranged from 1" to 1'-6". The lateral rootlets were also fewer as compared to the roots of plants growing in gravel. The lateral roots are given out at all levels but they do not branch much laterally but pass downwards (Fig. 3). This may be due to the fact that the soil is more compact and aggregates of the soil are formed which do not allow quick and much penetration of the roots.

The plants do not need profuse branching of the roots in all directions on account of the water holding capacity of the soil. The angles of the fine particles of the soil hold water in films.

The development of the Roots in dry and wet conditions:—

The development of roots was studied under two different conditions of water supply. Two sets, of six pots each were taken. In both of these sets garden soil sifted through 3 mm. sieve was taken so that the texture of the soil may not be the interveining factor in the development of the roots. The pots chosen for sowing the seeds were porous, 6" high and 5" in diameter at the top. The seeds collected in 1952 from the plants growing in the college compound were sown in all the pots in the same date (19. 7. 1953). The pots were kept in the garden in open, getting sunlight for the whole day. Approximately equal quantity of water was given to the first set after every twelve hours, but to the second set at intervals of 48 hours. The roots of two plants from each set were removed and drawn to scale every fourth day. The results of the experiment are given in table No. 1.

TABLE No. 1.

Development of root syetem in different water supply:—

Date	Water supply after every 24 hours.		Water supply after every 48 hours.	
	Mean length of the Primary root	Mean length of the Secondary root	Mean length of the Primary root	Mean length of the Secondary root.
23-7-53	2·0"	1.6"	4.8"	1.4"
27-7-53	2.8"	2.8"	3.6"	3.4"
31-7-53	2.8"	3.6"	2.0"	8.0"
4-8-53	4.0"	6.0"	5.6"	9.5"
8-8-53	6.0"	8.8"	10.8"	0.0"
12-8-53	4·0"	11.0"	8.6"	1.6"

From the above observations it is inferred that the development of root system has a definite relationship to the availability of water. In scanty water supply the development of the root (Fig 5) (primary as well as secondary) is more than those of plants that were growing in sufficient water supply (Fig. 4).

The root development of the plants which were growing in the gravelly substratum in the college garden was also studied. The roots of a single plant were traced on every fourth day and the figures were drawn to scale (Fig. 6.) Here the peculiarity noted was a comparative small length of the tap root and profuse branching of the secondary roots. The area occupied by the root system was more as compared to the roots of those plants that were growing in garden soil.

Thus the root system of the plant in different ecological habitat shows considerable variations. During development the root system adapts itself to the nature of the substratum and the amount of water available. The results are summarised below.

TABLE No 2

Nature of the root system in different types of soils.

S. No.	Nature of the soil.	Nature of the root system.	
		Primary	Secondary.
1.	Sand	Long and deep	Profuse and deep
2.	Gravel	Small and shallow	Profuse and shallow
3.	clay	Medium and shallow	Medium & shallow

Root Development of Gynandropsis Pentaphlla DC

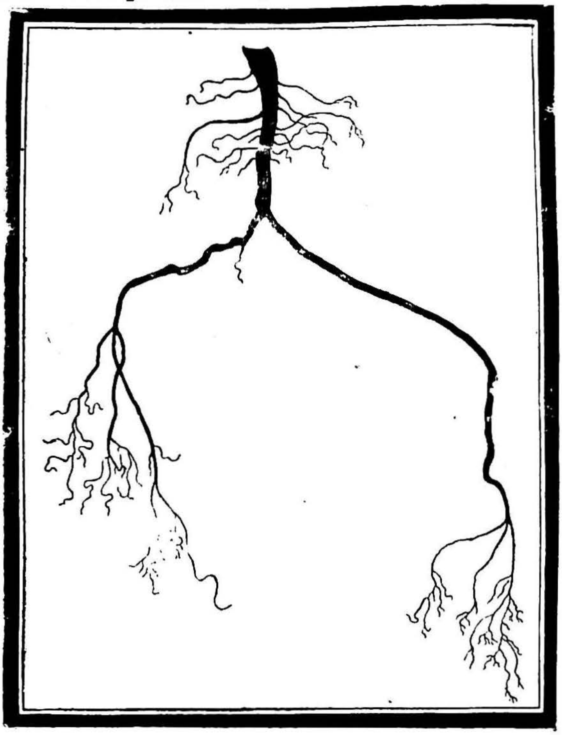

Fig. 1 (In Sandy Soils)

Fig. 2 (In Gravel)

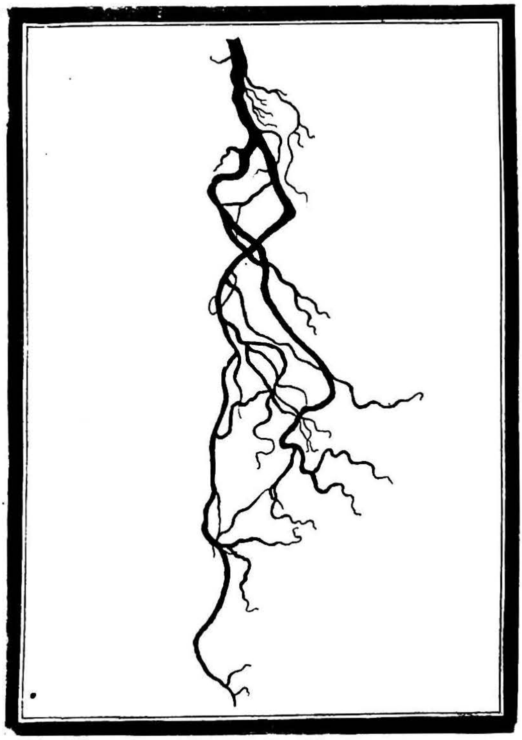

Fig. 3 (In Clay)

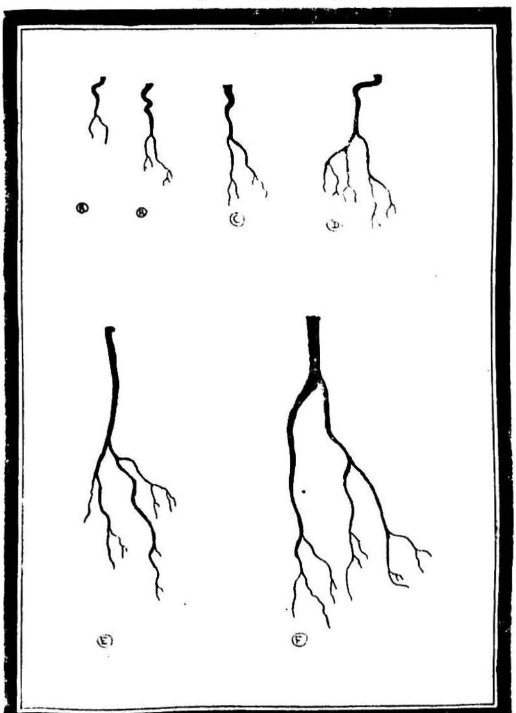

Fig. 4 (with sufficient Water Supply)

Gynandropis Pentaphylla DC.

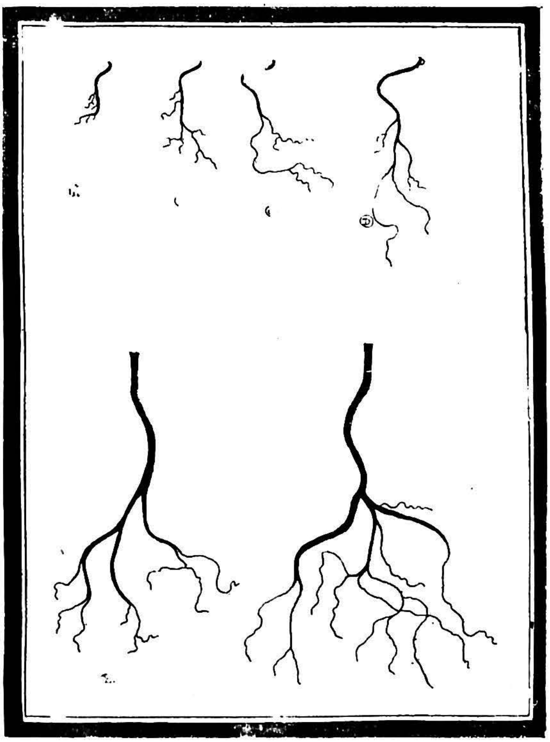

Fig. 5. (with Scanty water supply)

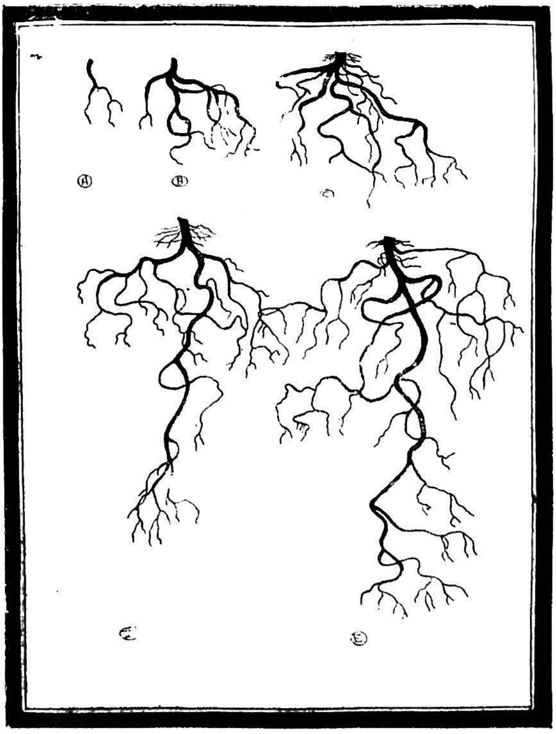

Fig. 6 (In Gravel)

3

Plant life in relation to Soil in Jodhpur & its neighbourhood.

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Contents:

INTRODUCTION.

It is widely recognised that normal vegetation may vary greatly and distinct plant communities grow within a radius of few miles. These differences are attributed to the differences in the nature of the soil. The study of the vegetation of India in relationship to soil types has not received much attention. A study of the soil in relation to plants in Jodhpur was, therefore, undertaken.

The sub-continent of India consists of four different soil groups:—

1. Laterite Soils:—as found in Deccan Peninsula, Bihar, Bengal, Assam etc.
2. Charnozems Soils:—as found in major portions of Central India.

3. Chestnut & Brown Soils:—as found in Upper Gangetic plains.
4. Sierozems & desert Soils:—as found in Sindh & Rajputana.

The general topographical aspect of Jodhpur is a sucession of dry undulating sandy plains and sandunes. At various places in these plains rocks crop up. These are the schists of the Arawali Series. At some places these are covered with rocks of Mallanic Series which are of volcanic origin and on these rest the sand stones of Vindhyan Series. There are thus the following types of soils in Jodhpur:—

1. Rocks as in Kailana area and in the North of Jodhpur.
2. Rocky depressions with superficial clay deposits.
3. Sandy plains and sandues derived from sand-stones by the process of disintegration and combined with sand drifting action of N. W. winds as pointed out by D. N. Wadia (1939).

Ninety percent of rainfall in Rajasthan occurs during Monsoon season that is from June to September, as pointed out by Paramanik 1952. While winter showers are few, a characteristic feature of rainfall in Rajasthan is that there may be an interval of several days between two successive rainy days. This results in desiccation of the soil to such a limit that the vegetation that has come up after the first few showers may be scorched. The other climatic factors in Rajputana present extreme conditions which affect the vegetation in diverse forms.

In addition to the local environments a number of Soil factors, such as (a) Soil temperature, (2) Water content, (3) Humus content, (4) pH value of Soil, play a significant role in determining the vegetation of the different parts of area.

PLAN & METHODS OF INVESTIGATION.

A thorough study of the physical and chemical nature of the soils of different localities of Jodhpur was made and results obtained for certain defined factors were tabulated. The vegetation growing was noted by *quadrat method* and ecological herbarium prepared co-relating to soil factors under three regions:—

1. Surface 0″ soil.
2. 6″ deep soil.
3. 1′ deep soil.

The physical and chemical nature of soils were analysed according to Piper (1949) and Lutz H. J. (1938).

OBSERVATION.

(a) Study of soils of different areas.

(i) Physical aspect.

1. Rocky area:-This area shows two main soil types (a) Rocky and (b) Clayey—in depression. All these soils are poor in water. The water content is usually greater in rainy season reaching upto 4. 5% and generally increases with depth. In the areas where the soils show clayey depressions the water content reaches upto 15%. The Humus, porosity and aeration of these soils are not very different from each other. The humus percentage is low and is usually larger in surface layers. The value for this factor decreases with depth of soil. During the winter season there is an increase in humus content and decrease in water content. Aeration and porosity do not show any change to a marked extent except that texture and aeration increases with depth and porosity decreases with depth. Structure of the soil types also does not change much.

2. Sandune areas:—The soils in these areas are sandy and single grained lying loose. The humus content is very low and does not exceed 2%. There is usually a decrease of humus percentage from deeper layers. This results in poor water holding capacity. The water content of surface soil is low. This gradualy increases with depth. Porosity and aeration show increase with depths and the values for these factors are different in studied areas.

Sandunes near Mussooria are surrounded by hills and show less porosity in contrast to sandunes near an Aerodrome which are situated in plains.

During winter season the water content decreases but its value increases with depth. There is a general increase in humus content during dry winter season. Aeration and porosity do not show much change in the winter.

3. Luni River bed:-The soils in this area are primarily saline and sandy and show single grained structure. The humus content is relatively poor and reaches upto 3. 5%. The water holding capacity

is fairly rich ranging from 10 to 26% and increases with depths. The percentage of humus is relatively low in rainy season. Porosity and aeration values approach those of the sandy soils in plains.

There is a considerable decrease in water content in winter season, specially in surface layers. It increases in subsoil layers. The humus content is not much in surface layers during winter. These are generally more in sub-soil layers. Porosity and aeration almost resemble values for soils in plains in winter.

4. Gottan:—This area is characterised typically by calcarious sandy soils with single grained structure. The humus content is very little and does not exceed 1% in rainy season. The percentage of water content in rainy season is fairly rich reaching upto 16%. The porosity and aeration values are more in comparision to sandy soil types.

During winter the humus percentage increases slightly in surface layers. The percentage of water content decreases during winter but its value increases from surface to sub-soil layers.

(ii) Chemical aspect.

Rocky area:—The typical rocky and clayey soils in this area contain fairly-rich amount of carbonates, chlorides and nitrates while the sandy soils contain lesser amounts. Exchangeable bases like potassium, calcium, water soluble salts and total cations do not show much difference. There is generally an increase in percentage of water soluble salts and total cations with increase in depth but at deeper layers their value is low. The pH of soils is uniform and ranges between 7.5 to 8. During winter there is a decrease in pH, water soluble salts and total cations. The soils of the clayey types in this area hold more of cations in comparision to rocky and sandy soils. The figures show a considerable decrease in the values for carbonates, chlorides and nitrates during winter season.

2. Sandunes:—The soils in this area are relatively poor in carbonates, chlordies; and nitrates; calcium content is also low while potassium is relatively high. Exchangeable bases are uniform throughout. Total cations increase from surface to the sub-soil layers. The soluble salts are more in comparision to rocky areas. The pH ranges from 7.5 to 8.

The values for the carbonates, chlorides, nitrates and calcium during the winter do not show much variation from the rainy season, while potassium decreases during winter. Similar is the case with water soluble salts and total cations.

3. Luni River bed:—Carbonates and chlorides are richly represented in this soil while the soil is poor in nitrate content. Calcium, potassium are present in greater quantities. Total cations are low. Water soluble salts increase from surface to sub-soil layer and their value is considerably low. The pH during rainy seasons varies from 7.5 to 8.

Due to evaporation from surface soil chlorides and carbonates are brought to surface layers during winter. This ultimately results in an increase in total cation contents, percentage of water soluable salts, also the pH which reaches as high a value as 9.5, as a result, the soils are more alkaline during winter.

4. Gottan:—The soils in this area are calcarious and contain abundance of carbonates; chlorides cotent is not so much as in the Luni River bed area. Nitrates are fairly well represented. Calcium is the most abundant exchangeable base while potassium is quite frequent in several quadrats. The total cations show variation from quadrat and generally they are considerably high. The soils seem fairly alkaline specially during winter season when pH value reaches as high as 10-5. There is usually a decrease in the content of carbonates, chlorides and nitrates during winter season. The total cations are generally high during winter season in comparison to summer season.

A consideration of above facts shows that soils in the investigated areas may be classified into the following types on the basis of their physical and chemical nature:—Physically, they may be classified as *rocky, sandy* and *calcareous*; on the basis of their chemical nature, they may be classified as *alkaline* and *nearly neutral*.

Taking into consideration the uniformity of soil types on the basis of their physical character and the origin of the soils in Rajputana, it may be safely concluded that the differences in soil structure in the different localities are mainly based up on their chemical nature. Alkaline soils in this area are represented in Gottān and Luni River bed soils. These soils contain considerable amount of chlorides, carbonates, calcium and potassium. Nitrates are fairly represented in these soils. The pH value in these areas varies from 9 to 10.5 in many quadrats. Neutral soils are represented in the rocky areas of Kailana and sandy areas of Mussooria and Aerodrome. The pH value of these soils does not exceed 8.

They differ from alkaline soil in having fairly good amount of nitrates while chlorides and carbonates are poorly represented. The presence of calcium and potassium is not to the same extent as in alkaline soils.

(b) Vegetation type & their frequency in different Soil types:—

A consideration of the above data leads to the following generalisation:--

1. There is an abundance of plant species during the rainy season in all the investigated localities.

2. During winter season the herbaceous vegetation is rather scanty and is represented by shrub and tree species only.

3. The rocky soils are characterized by characteistic associations of *Euphorbia royleana, Opuntia dillenii,* species of *Indigofera, Barlaria, Scirpus, Sericostoma, Asparagus* and *Grewia.*

4. The sandune areas are characterized by plant association of species of *Prosopis, Aerua, Leptadinia, Mollugo, Clerodenron, Gymnosporia* and *Gissekia.*

5. The saline sandy soils of Luni River bed support association of species of *Tamarix, Pluchea lanceolate, Farsetia* and *Gleome papillose.*

6. Calcarious soils of Gottan area support species of *Calotropis, Leptadinia, Vernonia, Cleomep usilla, Pulicaria* and *Celosia.*

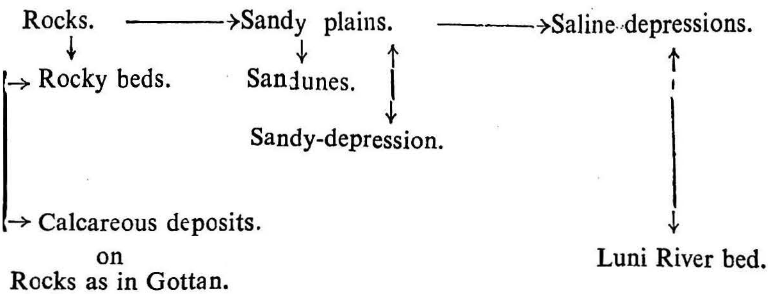
A critical examination of different physical and chemical factors of soils in different localities shows variations except in factors like (i) humus content (ii) exchangeable bases (iii) pH of the soil medium.

Other factors like water soluble salts, totalanions like chlorides, carbonates, nitrates, amounts of calcium, percentage of water content in soil, texture and structure of soil and porosity as well as aeration are adversely affected during the dry winter season. On the basis of this we can explain the rarity of plant species specially the herbaceous ones during the winter season.

Discussion.

(a) Ecologial status and considerations.

On the basis of the above observed factors it may be inferred that the rocky soils are characterstic and support distinctive vegetation much different from that of plains. The soils in other investigated localities appear to be interrelated with each other as represented in the diagram.



Vegetational inter-relationship of different localities.

The soil types in different localities nearly approach each other and so also the vegetational types. It is interesting to find which of the physical and chemical factors determine the vegetation growing in different localities. As pointed out earlier (1) the Water content and (2) the Amount of humus seem to be the chief physical factors controlling the vegetational growth. Among the chemical factors it is the amount of (1) Water soluble salts (2) pH value of soil which seem to effect the vegetation to a considerable extent and are the chief limiting factors. An improvement of above factors may result in a better type of vegetation in these areas.

Summary.

1. The nature of soils in different localities of the area is described.

2. The vegetation or plant communities in the above mentioned areas have been described.

3. The systematic vegetational inter-relations have also been discussed.

Acknowledgement.

This paper embodies some of the work incorporated in my thesis on "Plant life in relation to soil in Jodhpur and its neighbourhood", submitted in 1954 to the University of Rajputana in part fullfilment of the examination for the degree of M. Sc. I am grateful to the University for allowing me to use some of the matter from my thesis in this paper.

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REFERENCES.

Archibald 1949. The specific character of plant communities. Jour. Eco. *Vol. 37 No. 2.*

Blatter & Hallberg 1918-1921. Vegetation of Indian Desert. Jour. Bom. Nat. Hist. Soci. *Vol. 26-27.*

Byron T. S. 1952. Soil physical conditions & plant growth. Academtc Press. INC, Publishers, New York N. Y.

Chowdhary S.-P. Ray. 1953. Final reports of all India Soil Survey Scheme, Indian Coun. of Agr. Res. Bull. *No. 73.*

Hooker J. D. 1879. The FLora of British India *Vol. 1 to 6.*

Lutz. H. J. 1938. Forest soils.

Montasir A. H. 1938. Egyptian soil structure in relation to plants Bull. Sci. *No. 15*, Egyptian University.

Piper, C. S. 1950. Soil and Plant analysis. The University of Adelaide.

Puri G. S. 1943. The present position of plant of ecology desert of Rajasthan & Saurashtra.

Shanti Sarup 1952. Plant ecology of Jodhpur etc. Bull. Nat. Inst. Sci. India *No. 1*

Wadia, D. N. 1953 Geology of India, London (Macmillian & Co.)

4

Plant Ecology of Jodhpur Tehsil.

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Introduction:

The Indian desert lies in the north-west of Rajputana which is the largest State of the Indian Republic. The flora of the Indian desert is very little known and only slightly investigated. The earliest records of vegetation of the Aravalli ranges are by G. King (Indian Forester 1878) and Miss Macadam. In these publications we find lists of trees and shurbs. Adams also (1899) in a medico-topograhical and general account of Marwar, Sirohi and Jaisalmer State gave a list of indigenous and cultivated trees, shrubs and grasses along with their vernacular names. Survey by Blatter and Halberg (1819-21) of western Rajputana was also of a limited area and during particular season of the year--September to December. The area visited by them includes Jodhpur, Jaisalmer, Phalodi and Barmer.

Shanti Sarup and his colleagues have recently made several important contributions to the vegetation of western Rajputana. S. Sarup (1951) gave an account of the Plant Ecology of Jodhpur and its neighbourhood with a list of some common plants. S. Sarup and Dass (1951) contributed on the biological spectrum of Indian desert and pointed out that plant climate very nearly resembles that of Libyan desert and Cyrenaica.

Mulay and Ratnam with others have been engaged in ecological studies on the vegetation of Eastern Rajasthan.

A survey of previous work reveals that the account of the vegetation in several parts of Rajputana are mere random sketches without proper scientific approach, specially on the ecological side.

Several Indian Botanists like Agharkar, Biswas and Puri have referred to the importance of studies of the vegetation of the Indian desert in order to have a clear and definite understanding of the several problems facing the Indian desert. Accordingly, the vegetation of Jodhpur Tehsil was taken up for an extensive ecological study.

The Geological history of Rajasthan reveals that Rajputana was once covered by sea during Jurassic and Cretaceous and Eocene. The uplifting of the sea into dry land probably occured in the upper Tertiary. The occurrence of the desert conditions in Rajputana started about the year 4000 B. C. The archaeological evidences confirm the above facts.

TOPOGAPHY AND SITUATION.

Jodhpur Tehsil is almost the central area of Jodhpur division situated between latitude 26 to 27 and longitude 72.5 to 73.5. As pointed out by Pithawala (1952) this area comes under steppe desert section. Most of the area consists of plains which are characterized by the formation of depression of various dimensions. In the north are present several sand dunes of different sizes and shapes. The plains of Jodhpur Tehsil are situated at a height of 700-800 ft. above sea level. The presence of ditches and ponds is due to the torrential flow of rain water from the hill top to the plains during the rainy season. While the north-east part of the Tehsil contains several discontinuous hill chains. This tectonic group of mountainous chains are the upshoots of the Arawali ranges and do not reach a height more than 1200 ft.

A part of a Luni river bed also falls within this area. Its water is a litlle saline.

There are no natural tanks within the area. In the neighbouhood of Jodhpur their are several water reservoirs or Bunds, situated between the mountainous valleys where the rain water is collected and which forms the main source of water supply of the town.

CLIMATE.

The climate in the investigated region is typical of the other semiarid regions of Rajputana, it is characterized by low annual rainfall, the annual rainfall is usually below 14 inches. Most of the rains occur during July to September. Another characteristic feature of the climate is the great extremes of temperature. There is considerable difference between the winter and summer temperatures. The low precipitation and the high temperatures result in the dry climate which is characterized by low relative humidity. The relative humidity in cold season is 25% to 60% and 10% to 60% in hot months. The relative humidity markedly increases during the monsoon season.

The above features are further aggravated by high wind velocity with dust and thunder storms during different parts of the year resulting in the erosion of soil and the shifting of sand from place to place.

SOIL.

Physical and chemical analysis of the soil at different representative areas reveals that main disturbing factors for the development of vegetation are the sandy nature of soil and its low water content. The soils are fairly rich in carbonates, chlorides and also exchangeable bases like magnesium, calcium and potassium. They are usually deficient in nitrates. The hydrogenion concentration is on the alkaline side and it ranges from 7 to 9. 5. The highest value being that of Luni river bed. As a result of dessication the nitrates and water contents of soil decrease while the hydrogenion concentration and base exchange capacity are not much effected. Water content gradually increases from the surface to the deeper layers. Humus content in the soil has been found to vary from season to season and the largest value is during the winter months. In the following hot dry season very little humus has been observed and this may be due to the fact that blowing winds might have shifted that accummulated humus of the previous season.

FLORISTIC COMPOSITION.

The present ecological survey reveals several interesting features. The area under consideration has been divided into following Ecological areas:—

1. Rocky.
2. Plains.
3. Sand dunes.
4. Saline river bed.
5. Aquatic.

The characteristic features of rock Vegetation are associations of *Euphorbia* which grows on barren rocks. The distribution of these *Euphorbia* associations does not present any zonational aspects to the rock vegetation since they are present at all levels. Other common plants of this group are *Gymnosporia emarginata, Zizyphus rugosa, Anogeissus pendula* and several species of *Acacia*. The ephemeral vegetation of this region include species of *Tephrosia, Abutilon, Sida, Barleria, Corchorous, Tribulus, Heliotropium, Pupalia,* and *Commelina.* The important grasses are *Cenchrus, Aristide* and *Chloris.*

The plains show a vegetation much different to rock vegetation. The perennial species of this region includes mainly *Capparisappylla, Prosopis specigera,* and species of *Salvadora, Calotropis, Acacia, Leptadenia* and others. The rainy season vegetation is characterized by species of *Gynandropsis, Tephrosia, Mollugo, Trianthema, Solanum, Argemone, Boerhaavia* and variety of grasses. In plains the ephemeral vegetation does not continue beyond the months of October and November.

In well developed sand dunes *Calligonum polygonoides* was seen to be dominant along with *Aerua, Ephedra foliata, Mimosa hamata* and *Zizyphus rotundifolia.*

The vegetation of saline Luni River bed is not conspicuously different from that of plains as the salinity is not so high. The important plants of this area are *Tamarix, Suaeda, Cyperus, Pluchea lanceolata,* with species of sandy plains like *Aerua, Leptadenia, Indigofera* etc.

The several ecological plant associations recognized growing in different situations are as follows:—

(A) PLANT ASSOCIATION ON HILLS.

1. *Euphorbia-royleana Linn* d

2. **Euphorbia-Zizyphus association.**

Euphorbia-royleana Linn	d	*Zizyphus-rugosa Lamak co.*	d
Sericostoma-brevistigma stocks	r	*Asparagus-racemosus willd*	r
Achyranthus aspera Linn	a	*Grewia asiatica Linn*	a
Capparis-aphylla Roth	c	*Cleome viscosa Linn*	a
Cyndon-dactylon pers	a	*Cryptostegia grandiflora*	a

3. **Opuntia-Euphorbia association.**

Opuntia-dillenii Har	d	*Euphorbia-royleana Linn*	d
Grewia populifolia Linn co.	d	*Cenchrus biflorus Sweet*	a
Achyranthus aspera Linn	c	*Evolvulus-alsinoides Schwwinf*	a

(B) PLANT ASSOCIATIONS ON PLAINS.

1. **Gymnosporia Capparis association.**

Gymnosporia montana, Benth	d	*Capparis aphylla, Roth co.*	d
Acacia rupestris, Stocks co.	d	*Ephedra foliata, Staph*	a
Boerhaavia grandiflora rich	c	*Crotolaria burhia Dill*	c
Leptadenia spartium, wight	c	*Aristida paradisca, Retz*	a

2. **Capparis Leptadenia association.**

Capparis aphylla, Roth	d	*Leptadenia spartium, wight*	co. d
Gymnosporia montana, Benth	co. d	*Aerua tomentosa Frosk*	c
Zizyphus rugosa	a	*Crotolaria burhia Dill*	c
Boerhaavia diffusa	a	*Tephrosia purpurea pers*	a
Gynandropsis Pentaphylla Dc.	a	*Digera arvensis Forsk*	a
Leucas aspera spr	c	*Setaria glauca Beauv*	a

3. **Tephrosia Gynandropsis association.**

Tephrosia purpurea pers	d	*Gynandropsis pentaphylla Dc.*	co. d
Tribulus terrestris, Linn	a	*Eupherbia microphylla, Linn*	a
Cenchrus biflorus, Roth	a	*Chloris barbata Trin Swartz*	a

4. **Solanum Argemone association.**

Solanum Xanthocarpum Dun	d	*Argemone, mexicana Linn*	co. d
Solanum indicum Tourn	r	*Gynandropsis pentaphylla Dc.*	co. d

(C) PLANT ASSOCIATIONS ON SAND DUNES.

1. **Caparis Calligonum association.**

Capparis aphylla Roth	d	*Calligonum polygonoides Linn*	co. d
Leptadenia spartium wight	a	*Calotropis procera R. Br.*	c
Chlorisbarbata Trinswartz	a	*Sida cordifolia Linn*	a

2. **Crotolaria Aerua Association.**

Crotolaria burhia Dill	d	*Aerua tomentosa, Forsk.*	co. d
Polygala abyssinica R. Br.	a	*Cenchrus biflorus Roxb*	a
Mollugo hirta Thumb	c	*Tephrosia-purpurea Pers.*	a
Trianthema monogyna, Linn	c		

(D) PLANT ASSOCIATION ON SALINE RIVER BED

1. **Tamarix association.**

Tamarix-dioica Roxb	d	*Farsetia Jacquemontii Hook*	c
Tamarix gallica Vahl	co. d	*Suaeda fruticosa Forsk*	a

2. **Haloxylon-Atriplex association.**

Haloxylon Salicornicum Bunge	d	*Atriplex crassifolia*	co. d
Suaeda fruticosa Fosk	a	*Chenopodium album Linn*	a
Digera arvensis Forsic	c	*Amarantus spinosus Linn*	a

(E) AQUATIC ASSOCIATION.

1. **Eichornia-Potamogeton association.**

Eichornia, crassipea Kunth	*d*	*Potamogeton crispus Linn*	*co. d*
Lemna polyrrhiza Linn	*c*	*Microcystis sps.*	
Spirogyra sps.		*Oedogonium sps.*	
Wolffia arrhiza, wimm	*r*		

2. **Hydrilla Vellisneria association.**

Hydrilla verticillata casp	*d*	*Vallisneria spiralis Linn*	*co. d*
Ceratophyllum demersum	*a*	*Chara sps.*	
Nitella sps.			

The vegetation in these areas has also been studied from successional point of view. The relationship between the different plant communities has been closely followed and their successional relationships has been outlined. The plant associations that grow in sandy plain areas may be taken to represent the starting point. There is a continuous stream of climax and disclimax development from this starting point one of the disclimaxes results due to the shifting of sand by winds. The other type of disclimax is of physiological nature brought above by the saline rainwater along the Luni River Bed. Another type of disclimax occurs on the dry hills which seems to be due to the effect of several factors—climatic factors such as wind and drainage of the soil by rain waters. The climax developments are represented by plant association growing in the loamy plains, mixed hill and plain areas, and associations that grow along the moist rock areas.

The Bryophytic and Pteridophytic vegetation is mostly represeted in the rocky areas during rainy season only. They include species of *Riccia, Funaria Actinopteris* and *Marsilia.*

Gymnosperms are represented only by one species of *Ephedra foliata.*

The Algal vegetation is fairly rich and is represented by majority of myxophyceae and chlorophyceae. It is interesting to note that some of those rare algae such as *Characiosiphon, Fritschiella, Gongrosira* and *Tetrasporidium* grow in this region.

Discussion.

The situation of Jodhpur Tehsil in western Rajasthan and its physiographic features, characterized by the presence of tectonic chains of mountainous groups, presence of sandy or Aeolean plains along with underground salinity gives a peculiar status to the existing vegetation.

Blatter & Halberg (1918-21) in their survey have recognized the rarity of plant species in this area and the semi-arid or arid nature of the vegatation. S. Sarup (1952) in estimating the status of vegetation in the neighbourhood of Jodhpur points out that the existing flora is an admixture of the Arabian and Indian element.

The hilly areas in this region possess quite a different status in their vegetation mainly because of the collection and retention of rain water in several large or small basins during the rainy season ; water is retained in such basins for almost the entire year and naturally more plant species can migrate and grow well in such areas.

The fact that the soil of this area can support quite a rich vegetation and that the aridity or semiaridity that exists in the area is mainly due to the water factor is supported by the following observations:—

1. There are several small plant associations that grow in the area in rainy season which are composed of a large number of foreign species.

2. Most of the rainy season annuals complete their life by the time the winter season sets in and when a low water content prevails in the soil.

3. The presence of more plant species in natural or artificial troughs or basins even in the plains.

4. Most of the plant species that grow in the area are annuals and there is a lack of considerable number of perennial species.

A comparison of the present vegetation with the flora of Arabia shows that there is a considerable similarity in the type and number of species in both the areas. The absence of palm species e.g. *Cocos* and *Areca* here may be due to the fact that this area is separated from the sea by a large distance. The number of plant species in the Arabian desert is much more as compared to the flora in the present region. In fact a comparative study of the western Rajasthan, eastern Rajasthan and Arabian desert show that there in much scope for improvement of vegetation in this investigated area.

Considering the above aspects it is but logical to conclude that the vegetation of the present area has the potentialities of development into a climax of tropical humid region but the only important draw back is the water table of the soil.

Summary.

1. The topography, situation and vegetation of Jodhpur Tehsil in Jodhpur Division of western Rajasthan has been described.

2. In studying vegetation and its relation to environment important ecological factors have been studied thoroughly.

3. Important plant associations growing on different situations are given.

4. Vegetation has also been studied from successional point of view.

5. It is concluded that the vegetation of the investigated area has the potentialities of development into a climax of thorn forest but the greatest draw back is the low water content of the soil. The improvement of vegetation can be effected by introducing drought loving species, such as *Prosopis Juliflora*

Acknowledgements.

I take this opportunity to express my sincere gratitude to Prof. Shanti Sarup, Jaswant College, Jodhpur, under whose constant guidance, the present investigation has been carried out.

I am also thankful to Prof. B. V. Ratnam for many helpful suggestions and constructive criticisms

LITERATURE CITED.

1. Bull, No. 1 Sept. 52 of N. I. of science. — Symposium on Rajasthan Desert.
2. Blatter & Hallberg (1918-21) — The "Flora of Indian desert" J. B. N. H. Society Vol. 26-27.
3. Mulay B. N. & Ratnam B. V. — Vegetation found round about Pilani Proc. I. S. Congress part IV, abstracts.
4. Shanti Sarup. — Plant ecology of Jodhpur and its neighbourhood N. I. S. Bull. No. 1 Sept. 52.

The Relation between Water-content, Choloro-phyll-content and the Rate of Photosynthesis under Intermittent Illumination.

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Introduction:

In studying she effect of light on the rate of photosynthesis, a new line of thought was contributed by Emerson and Arnold (1932) who found that the rate of photosynthesis increases in intermittent illumination as compared to continuous light. This concept is of great significance as it confirms the Blackman concept (1905) of the existence of two well defined stages in photosynthesis—the Blackman or Dark stage and light or photochemical stage.

The light factor, as shown by several workers, is important in understanding the mechanism of photosynthesis. It would give us an idea about the possible steps—Dark or Photochemical—that are likely to occur at various stages in the process.

The rate of photosynthesis is controlled by a set of various internal factors such as water-content and chlorophyll-content. A study to understand the relation between such internal factors and the intermittent illumination would naturally reveal whether that particular factor is involved in dark phase or in photochemical phase.

The present investigation is taken up to establish a relation between water-content, chlorophyll-content and intermittent illumination.

Historical:

A new line of research on the physiology of Photosynthesis was opened by the work of Emerson and Arnold (1932) who made measurements of photosynthesis in flashing light by using bright flashes of short durations separated by variable dark periods. According to their calculations the dark period showed an increase of about 400 percent as compared with the rate of photosynthesis in continuous light.

The efficiency of the intermittent illumination was later confirmed by Clendehning and Ehrmantraut (1950) in their work with Chlorella.

The effect of some internal factors like water-content and chlorophyll-content in the photosynthetic process have received critical study by various plant physiologists, during recent years.

The effect of the water-content of the assimilating tissue was studied by Ellie Otto (1939) in some lichens. This work shows that the assimilation of lichens is dependent upon water-content. An increase in dry weight with increase in water-content was obtained by Melville (1937) in tomato plants. Heinicke and Childers (1936) detected a decrease in rate of photosynthesis with decrease in water-content of the soil for apple leaves. Wood (1929) found no direct relation between water-content and amount of assimilation while Dastur (1925) observed a direct correlation. Walter Heinrich (1929) found a marked reduction in the rate of assimilation in *Elodea candadensis* when water was extracted from the plant material by keeping it on osmotically active salt solution.

The chlorophyll-content is another important factor in photosynthesis and perhaps the most complicated. There have been several investigations to study this factor in understanding the mechanism of photosynthesis and the possible role that it plays.

In studying the effect of increase in chlorophyll-content the problem is beset with several difficulties, mainly because it is an internal factor and it is not possible by easy means to bring about an increase in the chlorophyll-content of an organ since it is governed by genetical factor.

However, there have been attempts to study this factor after having come to know the composition of chlorophyll molecule and the external factors which favour the formation of chlorophyll.

The earliest work to see whether there exists any relation between the chlorophyll-content and the rate of photosynthesis is the one by Willstatter and Stoll (1918). They expressed the results in terms of Assimilation Number. The results obtained show that there is little influence of the chlorophyll-content upon the rate of photosynthesis.

Emerson (1929) demonstrated a fairly close relation between the cholorophyll-content and the rate of photosynthesis in his experiments with Chlorella by varying the chlorophyll content by variation in Iron supply. Fleisher (1935) repeated the experiments by varying Nitrogen and Magnesium since these elements also enter iuto the molecule of chlorophyll. With Iron the data showed a direct relation between chlorophyll-content and photosynthesis; he further proved that there does not exist any direct relation when the chlorophyll content is varied by varything amounts of Nitrogen and Magnesium.

The above observations of Fleisher have been confirmed by Kennedy (1940). Emerson (1930) showed that chlorophyll plays a chemical part in photosynthesis working with Chlorella cells having different amounts of chlorophyll. Van Hille (1938) working with *Chlorella pyrenoidosa* showed that constant light and temperature ravour chlorophyll formation but check the rate of photosynthesis. Pickett and Kenoworthy (1940) have shown in their experiments with apple leaves that it is the internally exposed surface rather than the chlorophyll-content which is an important factor governing photosynthetic activity.

Emerson, Robert and others (1940) found that during photosynthesis under flashing light, the maximum amount of carbondioxide reducible does not appear to be directly related to the amount of chlorophyll present but depends upon some other internal factor.

Dastur and Desai (1933) studied the water-content and chlorophyll-content factors in relation to photosynthesis under different temperatures and pointed that there is a closer relation between the water-content and the rate of photosynthesis than between the chlorophyll-content and the rate of photosynthesis.

Materials and Methods:

The materials chosen for the present investigation include the following five plant species specially grown in pots:—

1. *Ricinus communis.*
2. *Gossypium herbaceum.*
3. *Colocasia sp.*
4. *Byrophyllum calycinum.*
5. *Deiffenbachia magnificus.*

The plants were kept watered from time to time in order to ensure that the plants are grown under normal water requirements. The soil in which the plants were grown is a good garden soil with all essential mineral elements so that the chlorophyll formation proceeded normally.

The rate of photosynthesis was measured in attached leaves by the continuous current method as devised by Dastur (1925,1933) with only minor modifications (fig. 1). In order to maintian the constancy of experimental conditions the same leaf was used throughout for one set of observations. The rate of photosynthesis was measured by the amount of carbondioxide taken per hour by the leaf. The source of carbondioxide was ordinary atmospheric air

The source of illumination was 1000 watt G. E. Edison gas filled lamp kept at a distance of 45 cms. from the leaf chamber. The temperature was maintained constant throughout the course of investigation at 25°c. within a range of 2-3 degrees.

The pressure was kept constant throughout the course of investigation by regulating the flow of air stream and connecting a manometer within the system.

The illumination was made intermittent by using cardboard disks pasted with black paper between the source of illumination and the plant chamber. Sectors of definite angles were cut in the disks and they were revolved at a speed of 725 r. p. m. with the help of a 1/6 H. P. Electric Delco Motor. (Fig. 2) Various light and dark periods were obtained by cutting sectors at different angles.

The carbondioxide absorbent used was O. 1 N. solution of barium hydroxide kept warm by a 500 watt gas filled lamp as sugges-ted by Warburg (1926). The amount of carbondioxide absorbed by the alkali was estimated by titrating it against a standard oxalic acid solution of O. 1. N. strength.

Respiratory carbondioxide of the leaf was also determined for each set of observations in order to calculate the real rate of assimiltion.

When all the observations for a single leaf were completed, the leaf was detached from the plant and its area and water—content were determined.

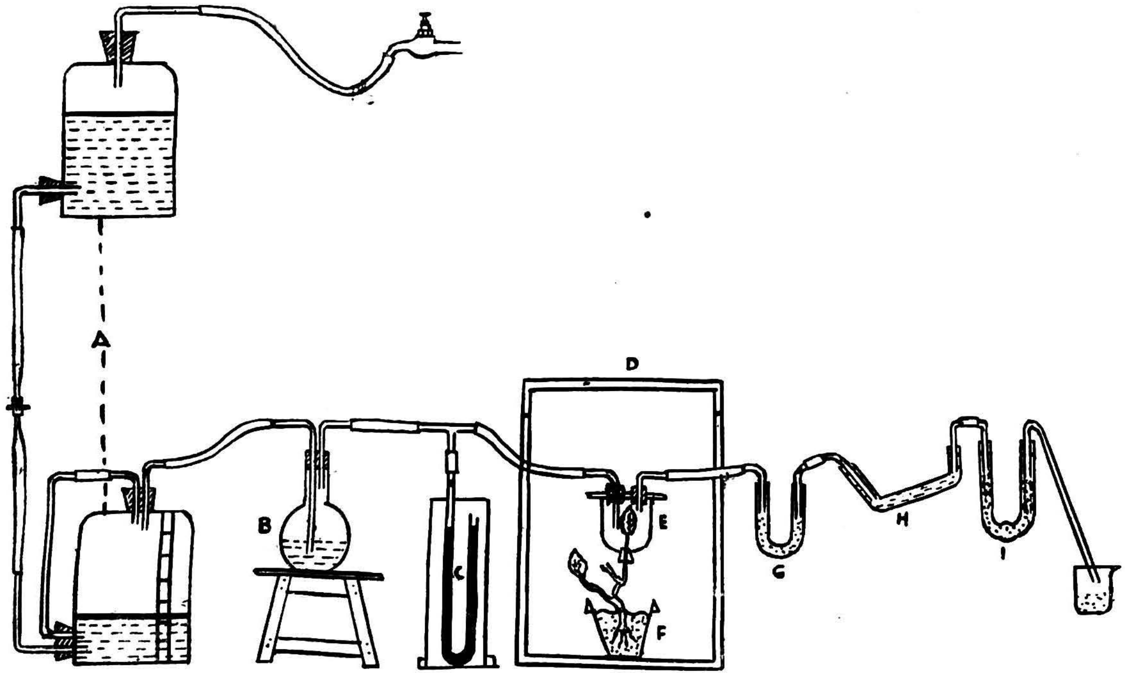


Fig. 1. Diagramatic represantation of the apparatus used excluding source of light and arrangement for intermittent illumination. A. Aspirators for supplying air. B. Sulphuric acid bubbler. C. Manometer. D. Plant Chamber. E. Leaf Chamber. F. Potted Plant. G. Calcium chloride U-tube H. Barium hydroxide (Co_2 absorbent) in pettinkoffer tube. I. Calcium chloride U-tube.

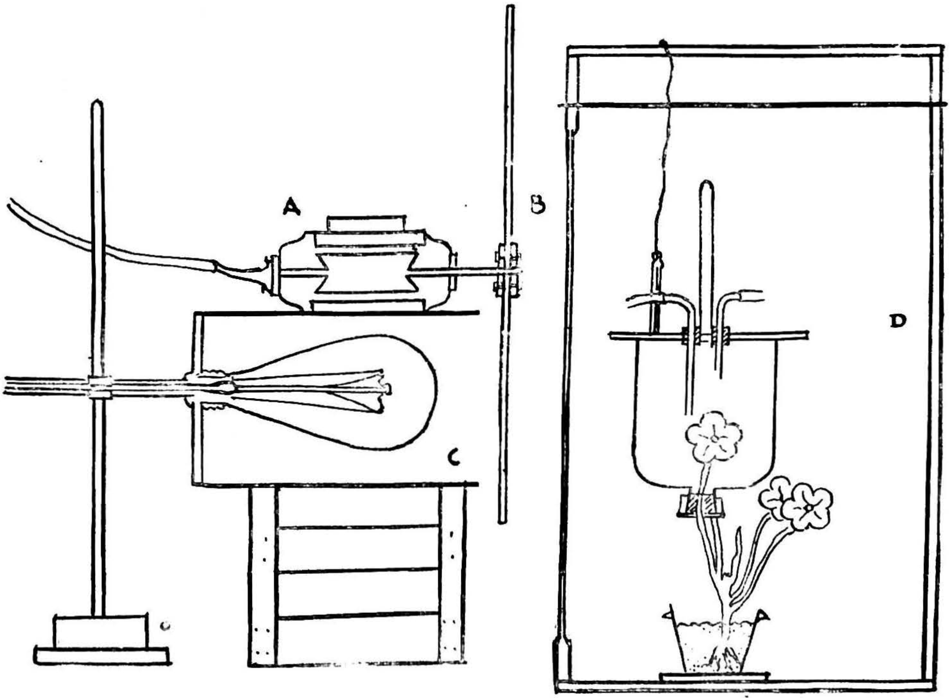


Fig. 2. Diagramatic representation showing arrangement for intermittent illumination.

A. Electric Motor. B. Revolving cardboard disk in Section. C. Source of illumination. D. Plant Chamber and Leaf chamber.

The completely dried leaf was carefully powdered for chlorphyll extraction and the amount of chlorophyll was determined after extracting it as ethyl chlorophylide.

OBSERVATION.

The rate of photosynthesis in the present investigation is determined by the continuous current method and atmospheric carbondioxide was supplied in a definite quantity per hour. The total amount of carbondioxide available in the air stream was first estimated before the commencement of each experiment. The amount of carbondioxide taken in by the leaf at the following light conditions was estimated in each species :—

1. Continuous light.
2. Intermittent illumination with disk No. 1 where the duration of the dark period was double that of the light period.
3. Intermittent illumination with disk No. 2 where the duration of the dark period was three times that of the light period.
4. Intermittent illumination with disk No. 3 where the duration of the dark period was four times that of the light period.
5. Intermittent illumination with disk No. 4 where the duration of the dark period was five times that of the light period.

After the above series of observations ware made for each leaf, the amount of respiratory carbondioxide for each leaf was determined in order to obtain the value for real assimilation. Subsequent to the above observations the area of the leaf, water-content and the chlorophyll-content were obtained.

The data above obtained are tabulated for each species (Tables 1 to 5) to give an idea of the Assimilation Numbers W and CH under the various light conditions. The assimilation numbers W and CH obtained as per method devised by Dastur and Desai (1933) may be expressed by the following relations :—

$$W = \frac{\text{Carbondioxide per sq. cm. of the leaf area in one hr.}}{\text{Water-content per sq. cm. of the leaf area.}}$$

$$CH = \frac{\text{Carbondioxide per sq. cm. of the leaf area in one hr.}}{\text{Chlorophyll-content per sq. cm. of the leaf area.}}$$

The results so obtained are graphically represented for each species (Graphs 1 to 5) to show the relation between Assimilation Numbers W and CH and the various light conditions.

A critical consideration of the results obtained in the present investigation reveals the following facts :—

1. The effect of intermittent illumination is to increase the rate of photosynthesis in all the plants investigated. With increase in the dark period ranging between O. 055 Sec. to O. 069 Sec., an increase in the rate of assimilation was obtained. The corresponding range in light period was between 0.027 Sec. to 0.013 Sec.

2. A direct relationship between the duration of the dark period and the Assimilation number W was observed for all the plant species.

3. Similar direct relationship between the assimilation number CH and the duration of the dark period was observed for all the species.

4. Except in *Gossypium herbaceum,* it was observed that that there was a fall in both the Assimilation numbers W and CH when the dark period was increased beyond the duration in disk No. 3.

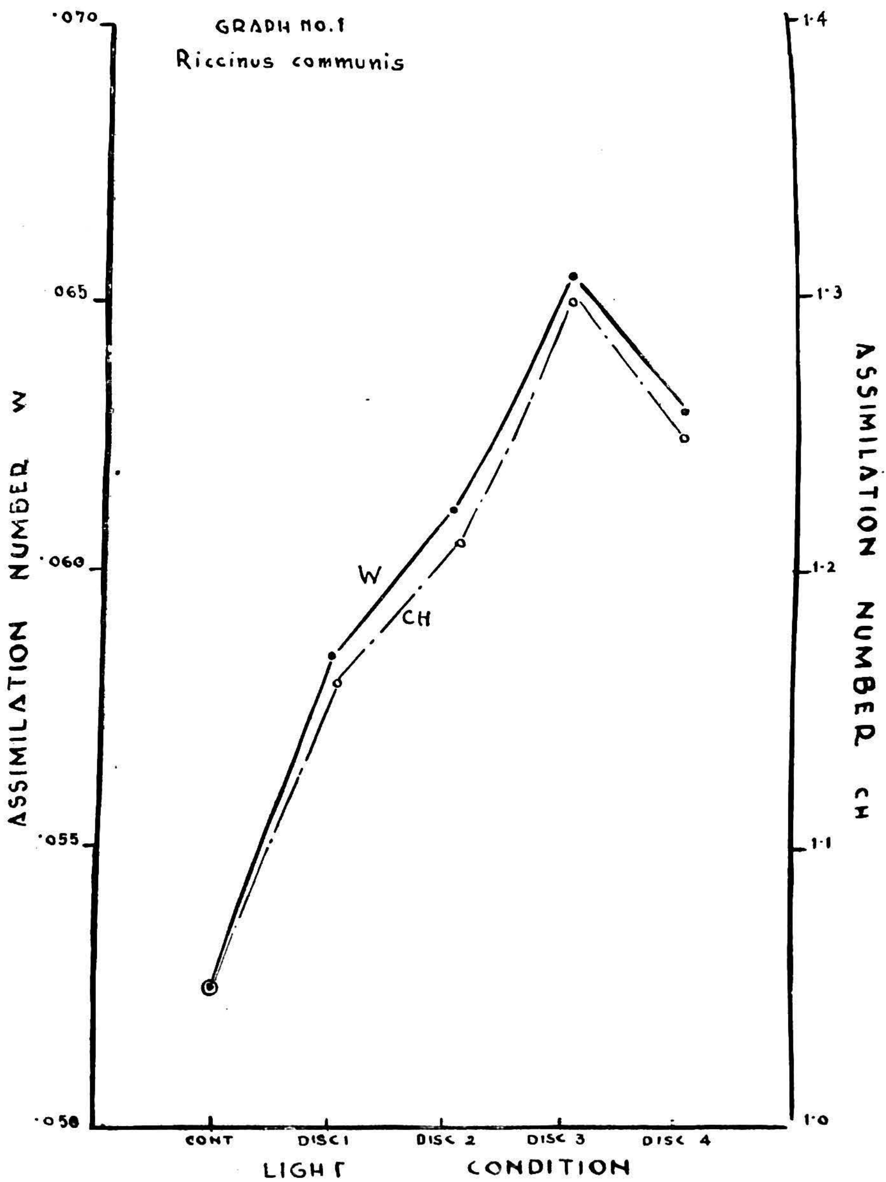
*** TABLE 1.**

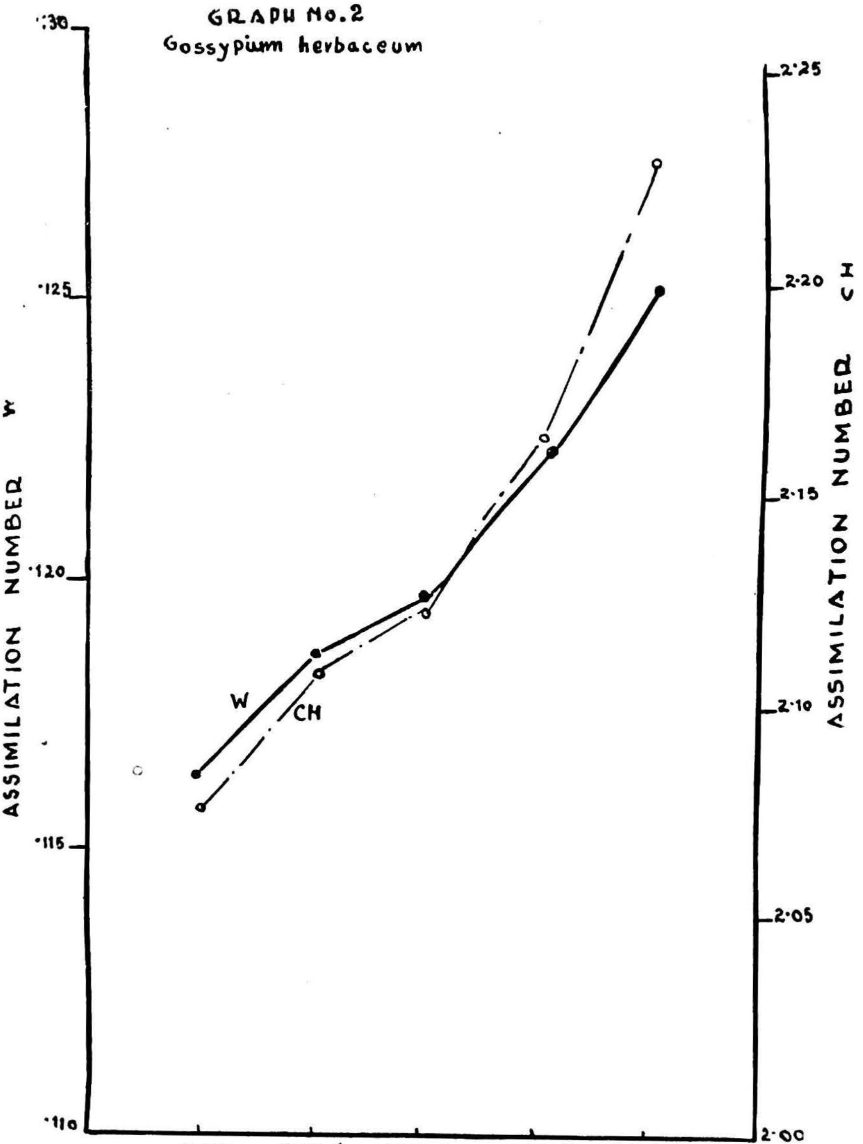
Ricinus communis.

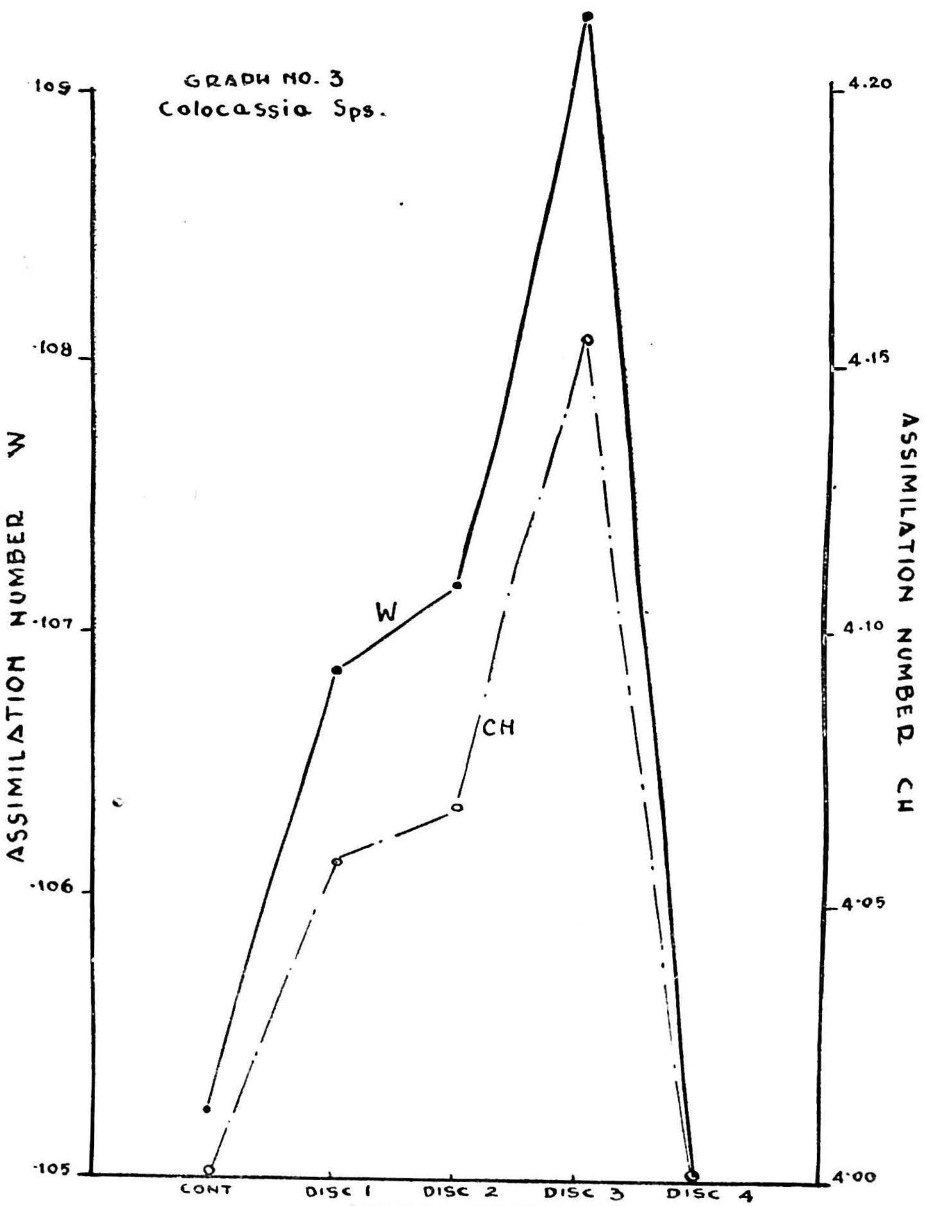
Area of the leaf	...	...	... 59.469 sq. cms.
Water-content of the leaf	...	...	... 948.800 mgms.
Water-content per sq. cm.	...	...	... 15.954 mgms.
Chlorophyll-content of the leaf		...	... 47.765 mgms.
Chlorophyll-content per sq. cm.		...	... 0.8032 mgms.

S. N.	Light condition.	CO_2 taken per sq. cm. per hr. in mgms.	Assimilation number W.	Assimilation number CH
1.	Cont. Light.	0.83856	0.05256	1.04403
2.	Disk 1.	0.93208	0.05842	1.16047
3.	Disk 2.	0.96941	0.06076	1.20694
4.	Disk 3.	1.04436	0.06547	1.30026
5.	Disk 4.	1.00691	0.06311	1.25363

*Represented in graph No. 1.


GRAPH NO.1
Riccinus communis
·070
·065
·060
·055
·050
ASSIMILATION NUMBER W
1·4
1·3
1·2
1·1
1·0
ASSIMILATION NUMBER CH
W
CH
CONT
DISC 1
DISC 2
DISC 3
DISC 4
LIGHT CONDITION


GRAPH No.2
Gossypium herbaceum
·130
·125
·120
·115
·110
ASSIMILATION NUMBER W
2·25
2·20
2·15
2·10
2·05
2·00
ASSIMILATION NUMBER CH
W
CH
CONT
DISC 1
DISC 2
DISC 3
DISC 4
LIGHT CONDITION



GRAPH NO. 3
Colocassia Sps.
ASSIMILATION NUMBER W
ASSIMILATION NUMBER CH
·109
·108
·107
·106
·105
4.20
4.15
4.10
4.05
4.00
W
CH
CONT
DISC 1
DISC 2
DISC 3
DISC 4
LIGHT CONDITION

* TABLE 2.

Gossypium herbaceum.

Area of the leaf	... ...	32.637 sq. cms.
Water-content of the leaf	... ...	802.200 mgms.
Water-content per sq. cm.	... ...	24.579 mgms.
Chlorophyll-content of the leaf	... ...	45.061 mgms.
Chlorophyll-content per sq. cm.	...	1.3806 mgms.

S.N.	Light condition.	CO_2 taken per sq. cm. per hr. in mgms.	Assimilation numbers	
			W.	CH
1.	Cont. Light.	2.87137	0.11682	2.07979
2.	Disk 1.	2.91660	0.11866	2.11256
3.	Disk 2.	2.94231	0.11976	2.13119
4.	Disk 3.	2.99927	0.12202	2.17244
5.	Disk 4.	3.08206	0.12533	2.23240

* Represented in graph No. 2

* TABLE 3.

Colocasia sp.

Area of the leaf	... ...	88.3005 sq. cms.
Water-content of the leaf	... ...	1157.60 mgms.
Water-content per sq. cm.	... ...	13.1097 mgms.
Chlorophyll-content of the leaf	... ...	30.45 mgms.
Chlorophyll-content per sq. cm.	...	0.34484 mgms.

S.N.	Light Condition.	CO_2 taken per sq. cm. per hr. in mgms.	Assimilation numbers.	
			W	CH
1.	Cont. Light.	1.37986	0.10525	4.00145
2.	Disk 1.	1.40112	0.10688	4.06310
3.	Disk 2.	1.40470	0.10715	4.07350
4.	Disk 3.	1.43326	0.10933	4.15630
4.	Disk 4.	1.37708	0.10504	3.99330

* Represented in graph No. 3

* TABLE 4.

Bryophyllum calycinum.

Area of the leaf	45.4725 sq. cms.
Water-content of the leaf	2914.80 mgms.
Water-content per sq. cm.	64.1001 mgms.
Chlorophyll-content of the leaf	31.124 mgms.
Chlorophyll-centent per sq. cm. ...	0.68432 mgms.

S. N.	Light conditions.	CO_2 taken per sq. cm. per hr. in mgm.	Assimilation Number	
			W	CH
1.	Cont. Light	0.48258	0.00752	0.70500
2.	Disk 1.	*0.53947	0.00824	0.77369
3.	Disk 2.	0.56019	0.00874	0.81861
4.	Disk 3.	0.71872	0.01121	1.05000
5.	Disk 4.	0.60314	0.00949	0.88124

* Represented in graph no. 4

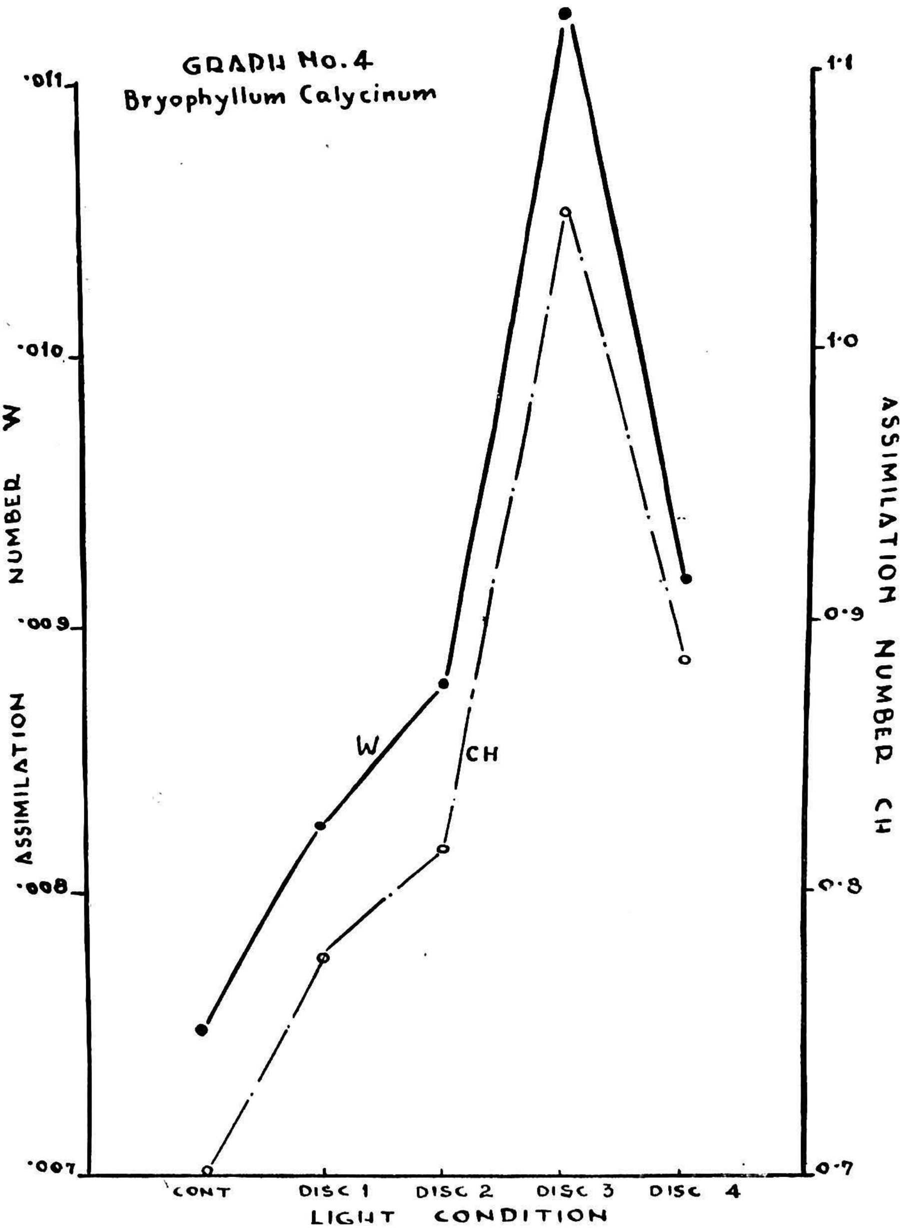
* TABLE 5.

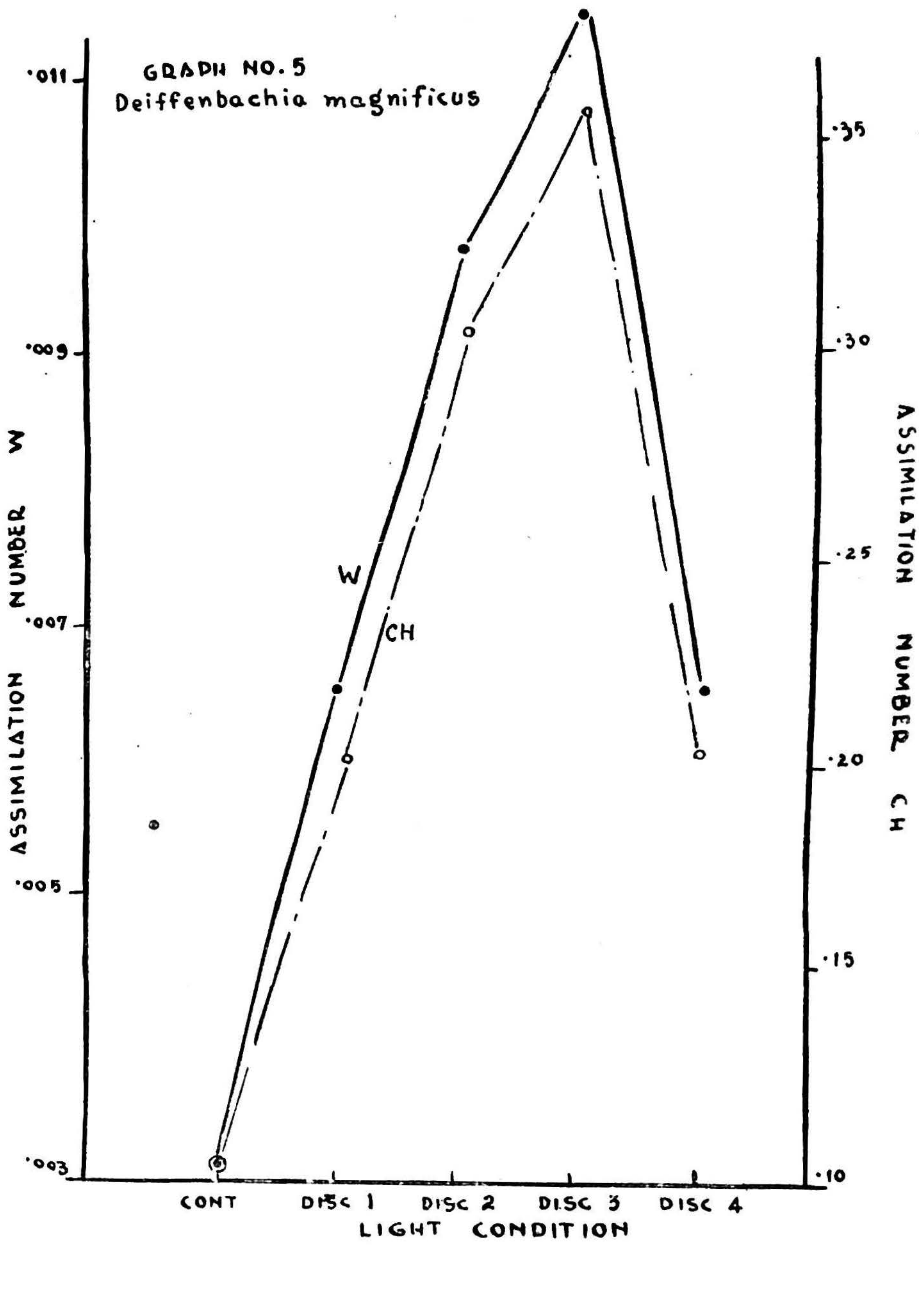
Deiffenbachia magnificus.

Area of the leaf	29.283 sq. cms.
Water-content of the leaf	700.200 mgms.
Water-content per sq. cm.	23.911 mgms.
Chlorophyll-content of the leaf	22.0332 mgms.
Chlorophyll-content per sq. cm. ...	0.75242 mgms.

S. N.	Light condition.	CO_2 taken per sq. cm. per hr. in mgm.	Assimilation Number	
			W	CH
1.	Cont. Light	0.07833	0.00327	0.10410
2.	Disk 1.	0.15522	0.00648	0.20629
3.	Disk 2.	0.23211	0.00970	0.30848
4.	Disk 3.	0.27055	0.01131	0.35957
5.	Disk 4.	0.15522	0.00648	0.20629

* Represented in graph No. 5.


GRAPH No. 4
Bryophyllum Calycinum
·011
·010
·009
·008
·007
ASSIMILATION NUMBER W
1·1
1·0
0·9
0·8
0·7
ASSIMILATION NUMBER CH
W
CH
CONT
DISC 1
DISC 2
DISC 3
DISC 4
LIGHT CONDITION


GRAPH NO. 5
Deiffenbachia magnificus
ASSIMILATION NUMBER W
ASSIMILATION NUMBER CH
·011
·009
·007
·005
·003
·35
·30
·25
·20
·15
·10
W
CH
CONT
DISC 1
DISC 2
DISC 3
DISC 4
LIGHT CONDITION

Discussion.

The role of some of the internal factors in photosynthesis is little understood till recently. The water-content and chlorophyll-content are the most important amongst them.

As pointed out earlier, several workers have shown that there is a direct relation between water-content and the rate of photosynthesis. Several investigations upon the chlorophyll-content in relation to the rate of photosynthesis show that there is little in it to emphasize. However, Emerson (1929) demonstrated a fairly close relation between the chlorophyll-content and the rate of photosynthesis in *Chlorella.*

Van Hille (1938) has shown that continuous light and high temperatures favour chlorophyll formation but check the rate of photosynthesis. These results are of considerable importance for the present investigation in view of the fact that continuous light retards the rate of of photosynthesis.

According to Emerson, Robert and others (1940) the rate of photosynthesis under flashing light did not depend upon the chlorophyll-content but is related to some other internal factor. The nature of this internal factor has not been discussed in their work. Dastur and Desai (1933) in their studies on the relation between water-content, chlorophyll-content and the rate of photosynthesis have shown that the water-content is a more important internal factor than chlorophyll content in determining the magnitude of the process at different temperatures.

The kinetics of photosynthesis have revealed the importance of chlorophyll in light reaction. Chlorophyll is regarded as an energy absorber as well as a hydrogen donator to the carbondioxide complex formed during dark reactions.

During the course of present investigation the chlorophyll-content and the water-content along with other factors were kept constant and changes were made only in the duration of light and dark periods. The results obtained show that there is a close similarity between the assimilation number W. and CH. This can be seen clearly from the graphs and tables.

The following quotations from the monograph on photosynthesis in plants by the American Plant Physiologists (1949) give us an idea about the probable role of the chlorophll and water-content in the photosynthetic Process.

"We feel reasonably sure of our postulation of the reduction of carbondioxide by hydrogen. We do not know whether chlorophyll is directly concerned in hydrogen transfer although we feel that it probably is.

"According to Frenkel (1941) the reduction of carbondioxide preceeds the dark fixation of carbondioxide in a product of moderately high molecular weight and considerable stability. This compouud is formed outside the chloroplasts and is therefore, not a chlorophyll-CO_2 complex.

"Willstater's (1913) early hypothesis assumed that the first compound was between chlorophyll and carbondioxide. A number of workers now suggest that there is not a direct chemical union between chlorophyll and carbondioxide at any time but that the carbondioxide complex is free to react with an activated hydrogen donor. And in this respect chlorophyll activated by light energy seems to fit in best"

Chlorophyll may now be regarded to act as a hydrogen donor to the reduction of carbondioxide molecule in a series of steps in the mechanism of photosynthesis as postulated by several authors. Here, the source of hydrogen for the chlorophyll molecule is the water available in the mesophyll cells of the leaf.

The activation of the chlorophyll molecule is a light reaction and in this stage hydrogen from water is accepted by the chlorophyll. The activated chlorophyll molecule with the hydrogen immediately transfers the latter in the next dark reaction to the carbondioxide-complex. Thus a series of light and dark reactions follow in the photosynthetic process.

The above discussion shows that the amount of hydrogen donated by water in the mesophyll cells of the leaf and the amount of hydrogen accepted by the chlorophyll containing plastids in the mesophyll cells of the leaf must be related to their quantitative values. This would naturally mean that the water-content and chlorophyll-content must be related to the intermittent illumination in determining the magnitude of the process.

The suggestion by Emerson and others (1940) that it is some internal factor other than chlorophyll-content that is important in carbondioxide reduction under flashing light, seems to be warranted and the author suggests that it is probably the water-content. Both water-content and chlorophyll-content are, however, equally important in relation to intermittent illumination.

That, "the carbondioxide assimilation of leaves is more closely related to the water-content than to the chlorophyll-content" (Dastur & Desai 1933), may be accounted for; these authors have considered constant illumination which, though favourable for chlorophyll formation, has a definite retarding effect on the rate of photosynthesis (Van Hille 1938).

Summary.

1. The relation between the water-content, chlorophyll-content and intermittent illumination in determining the magnitude of the photosynthetic process in some tropical land plants has been studied.
2. The rate of photosynthesis was determined in attached leaves by the type of apparatus suggested by Dastur and Desai with slight modification.
3. The relation between water-content and chlorophyll-content with intermittent illumination is expressed as assimilation numbers W and CH as suggested by Dastur and Desai.
4. The present observations reveal that there is a direct relation for both assimilation numbers W and CH with intermittent illumination.
5. The results obtained have been fully discussed and the importance of these results have been pointed out.
6. The present work establishes the importance of light and dark reactions in the photosynthetic process and the possible role of water and chlorophyll pointed out.

Acknowledgements.

I express my deep sense of gratitude to Prof. B. V. Ratnam, M. Sc.; F. B. S. Head of the Department of Botany, Dungar College Bikaner, for his valuable guidance and constructive criticism throughout the course of this investigation. I am also grateful to Dr. B. N. Mulay, M. Sc., Ph. D., F. B. S. Head of the Botany Department, Birla College Pilani for providing me the necessary laboratory facilities in his department where this investigation was carried out.

LITERATURE CITED.

1. Baly, 1940 — "Photosynthesis" Mathuen & Co., London.

2. Dastur, R. H. & Desai, B. L. 1933. — "The relation between water-content, chlorophyll-content and the rate of photosynthesis in some tropical plants" Ann. Bot. XLVII: 69–98.

3. Emerson, R., Robert, Lowell Green, & Eeyden Webb, J. 1940. — "Relation between quantity of chlorophyll and capacity for photosynthesis" Pl. Physio. 15 (2): 311–317.

4. Emerson, R., & Robert. 1930. — "The chlorophyll factor in photosynthesis". Amer. Naturalist. 64 (692): 252-260.

5. Fleischer, Walter, E. 1935. — "The relation between chlorophyll content and the rate of photosynthesis" Jour. Gen. Physio. 18 (4): 573-597.

6. Loomis, W. E. and Shull, C. 1937. — "Methods in Plant Physiology" McGraw Hill Book Co., New York.

7. Rabinowitch Eugene I. 1945. — "Photosynthesis and related processes" Vol. 1. Interscience Publishers, Inc. New York.

8. Stiles, W. 1950. — "Introduction to the principles of Plant Physiology" Mathuen & Co.

9. Van Hille, J. C. 1938. — "The quantitative relation between rate of photosynthesis and chlorophyll-content in *Chlorella Pyrenoidosa*" Rec. Trav. Bot. Neerland 35 (1) 680–757.

Some Ecological Observations On *Marsilea aegyptiaca* Willd*

By

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The state of Rajasthan possesses a varied climate. The temperature ranges from 80 °F to 120° F; so also the rainfall. The soil in different parts of Rajasthan is derived from a varied geological horizon, its condition ranging from the desert sand to fertile black soil. Jodhpur is situated more or less in the arid part of the state. *Marsilea aegyptiaca,* therefore, grows and thrives in a place with almost extremes of climate: hot summers, cold winters and scanty rainfall. *Marsilea* grows here in shallow waters during and after the rains (July and August to March). But as margins of the tanks begin to dry, it produces sporocarps. The latter mature and ultimately perennate during the dry season (February to July) until the rains. The habit of the plant naturally shows considerable variations and it was, therefore, thought worth while to make some ecological observations on this interesting water fern.

My study is brief. Qualitative analysis of soil and water from four different places within an area of eight miles from Jodhpur has been made. This is indicated in the following tables.

TABLE 1.

Qualitative analysis of water.

S. No.	Place & Date.	Basic radicals.	Acid radicals.	PH. value.
1.	Bijolai. 11-9-54	1. Magnesium. 2. Potassium. 3. Manganese. 4. Lead.	1. Sulphate.	×

*Part of the Thesis submitted by the author for his M.Sc. at the 1955 Examination of the University of Rajputana.

2.	Lalsagar Tank. 16-9-54	1. Calcium. 2. Potassium. 3. Magnesium.	1. Sulphate. 2. Traces of Carbonate.	5 (acidic)
3.	Bijolai Tank. 23-9-54	1. Magnesium. 2. Chloride. 3. Calcium. 4. Potassium.	1. Sulphate. 2. Carbonate.	8. (alkaline) after rainfall.
4.	Akheyrajji ka Tank. 23-9-54	1. Magnesium. 2. Calcium. 3. Potassium.	1. Sulphate. 2. Chloride. 3. Carbonate.	8. (alkaline) after rainfall.

TABLE 2.

Qualitative analysis of soil.

S. No.	Place & Date.	Carbonates.	Chlorides.	Nitrates.	Exchangeable bases.	Calcium.	Potassium.	Phvalue.
1.	Lal Sagar. 12-9-54	+++	++++	+	++++ absent.	+++	+++	8
2.	Bijolai 24-9-54	+++	++++	absent	+++ absent.	++	+	8
3.	Akheyrajji ka Tank. 29-9-54	++++	++++	++	++++ absent.	+++	++++	8
4.	Garden soil	+++	++++	+	++++ absent.	+	++	8

The water was analysed by simple qualitative methods whereas the standard methods were adopted for the analysis of soil in order to see if the growth was influenced materially under any specific conditions. No serious corelation between the growth of the plants and the water or soil content of the habitat could be well established. It was seen, however, that the plants from Bijolai were smaller and less gregarious in habit than those collected under similar conditions from Lal Sagar and Akhey Rajji ka Tank. This may be attributed to less Potassium content in the habitat at Bijolai.

Recent studies on *Marsilea,* particularly by Allsopp (1953-1955) on *M. Drummondii* show that the sugar content is very largely responsible for bringing about changes in the size and development of the vegetative organs, notably the leaves. He has observed in his experiments that leaf variations are brought about by changing the sugar content of the culture solutions. He finds that 4–5 per cent sugar solutions are best suited for the growth of the plants. The appearance of normal type of leaves in the seedling is influenced by this concentration. Less than the 5 per cent concentration delays this appearance of normal leaves.

The experiments are quite interesting by themselves; but I am not in a position either to verify that the same results will be obtained by such experiments on other species of *Marsilea* or whether Allsopp's experiments support Goebel's hypothesis, namely importance of nutrition as a guiding factor in the display of heteroblsty in plants. That the appearance of different type of leaves during the ontogeny of a plant may be attributed to nutrition phenomenon and not indicating any type of reversion to primitive condition cannot be accepted without reserve. If it was so that the nutrition plays such an important part, studies for other species of *Marsilea* by Allsopp would have been more profitable for a definite conclusion on the subject. Mahabale and Gorgi do not seem to support this nutritional theory of Goebel (1948).

The plants of *Marsilea* are notorious in exhibiting morphological plasticity in different environmental conditions and presenting quite a different appearance according to the seasons. This is clearly indicated in the following tables that demonstrate the great variation in the length of the vegetative organs of the plant. It is not uncommon to observe plants with different types of leaves even on the same rhizome that may be partly submerged and partly growing on the muddy margins of the aquatic habitat. It will be noticed that I have not cared to measure the internodes of these diverse plants for the lengths vary so greatly that no corelation of size and habitat may be possible.

TABLE 3.

Vegetative organs of *M. aegyptiaca* Willd.

N. B. The scale used is one in which one inch is divided in 16 parts.
(S = Subterrestrial & A = Aquatic)

S. No.	Locality.	General habit.	Root.	Petiole.	Leaflets.	Remark.
1.	Lal Sagar.	Subterrestrial.	3.3″	2.10″	.6/.7″	
			2.1″	2.8″	.6/.7″	
	a. Plant (S)		2.0″	2.8″	.5/.6″	
			1.11″	2.7″	.3/.4″	
			1.10″	2.5″	.3/.4″	
			1.9″	1.3″	.2/.4″	
			1·13″	0.15″	.2/.3″	
			1.5″	0.14″	.2/.3″	
			1.4″	0.13″	.2/.3″	
			1.1″	0.12″	.1/.2″	
2.	Lal Sagar.	Subterrestrial.	2.8″	1.12″	.3/.4″	
			2.7″	1.11″	.3/.4″	
	b. Plant (S)		2.5″	1.10″	.3/.4″	
			2.2″	1.9″	.3/.4″	
			2.1″	1.9″	.3/.4″	
			1.13″	1.8″	.3/.4″	
			1.10″	1.8″	.2/.3″	
			1.5″	1.8″	.2/.3″	
			1.4″	1.7″	.2/.3″	
			1.0″	1.7″	.2/.3″	

3. Lal Sagar. Aquatic, growing	1.5″	4.0″	3./.3″	slightly more
in shallow	1.4″	3.12″	.3/.3″	
c. Plant (A) water.	1.2″	3.12″	.3/.3″	
	0.15″	3.0″	.3/.3″	
	0.13′	2.11″	.2/.2″	
	0.10″	1.10″	.2/.2″	
	0.9″	1.6″	.1/1.″	
	0.8″	0.11″	.1/.1″	
	0.8″	0.11″	.1/.1″	
	0.7″	0.5″	.1/.1″	slightly less
4. Lal Sagar. Aquatic, growing	2.0″	3 14″	.3/.3″	slightly more
in shallow	1.6″	3.12″	.3/.3″	
d. Plant (A) water.	1.5″	1.10′	.3/.3″	
	1.4″	1.8″	.3/.3″	
	1.1″	1.5″	.2/.2″	slightly less
	1.0″	1.2″	.2/.2″	
	0.9″	1.1″	.2/.2″	
	0.8″	1.0″	.1/.1″	slightly more
	0.6″	0.13″	.1/.1″	
	0.5″	0.6″	.1/.1″	
5. Lal Sagar. Aquatic, growing	1.5″	3.4″	.3/.3″	
in shallow	1.1″	2.8″	.3/.3″	
e. Plant (A) water.	1.0″	2.5″	.3/.3″	slightly more
	1.0″	2.2″	.2/.2″	
	0.9″	3.0″	.2/.2″	
	0.8″	1.8″	.1/.1″	
	0.6″	1.2″	.1/.1″	
	0.5″	2.0″	.1/.1″	
	0.4″	0.15″	.1/.1″	
	0.4″	0.8″	.1/.1″	slightly less

6.	Chhitar Palace.	Subterrestrial and young.	2.6″	2.9″	.2/.3″
			2.4″	2.8″	.2/.3″
			1.9″	2.4″	.2/.3″
	f. Plant (S)		1.8″	2.3″	.2/.3″
			1.7″	2.3″	.3/.4″
			1.6″	2.12″	.3/.4″
			1.5″	2.2″	.3/.4″
			1.0″	2.0″	.3/.4″
			1.0″	1.7″	.3/.4″
			2.4″	1.6″	.1/.2″
7.	Chhitar Palace.	Subterrestrial and young.	2.2″	1.8″	.2/.3″
			2.0″	1.7″	.2/.3″
			2.0″	1.6″	.2/.3″
			1.9″	1.5″	.2/.3″
			1.8″	1.4″	.2/.3″
			1.7″	1.4″	.2/.3″
			1.7″	1.3″	.3/.4″
			1.6″	1.2″	.3/.4″
			0.10″	1.1″	.3/.4″
			0.9″	1.0″	.3/.4″
8.	Chhitar Palace	Subterrestrial. and Young.	3.12″	1.10″	.2/.3″
			3.4″	1.10″	.3/.4″
			2.10″	1.9″	.3/.4″
			2.6″	1.9″	.3/.4″
			2.4″	1.8″	.3/.4″
			2.0″	1.7″	.4/.5″
			1.14″	1.6″	.4/.5″
			1.12″	1.5″	.4/.5″
			1.5″	1.4″	.4/.5″
			1.0″	1.0″	.4/.5″

It has been shown elsewhere that the structure of the sporocarp both external and internal as well as the size and relation of the pedicel to the sporocarp are important features of morphology. The table below demonstrates clearly that the lengths of the pedicels in *M. aegyptiaca* is three or even four times that of the sporocarps. The latter being almost squarish in shape, the length of the pedicles also becomes three times that of the breadth of the sporocarp. This fact may be of real significance for this species and if such a ratio were to be discovered in any other form of *Marsilea*, the affinities of the two will have to be reckoned with. As far as our observations go, no such relationship is noticeable in any other Indian species except to some extent in *M. Condensata* Bak.

TABLE 4.

Sporocarpa of *M. aegyptiaca* Willd.

S. No.	Locality.	Length of stalk.	Size of the sporocarp.	Remarks.
1.	Lal Sagar. a. Plant (S)	.4", .4", .3", .3", .3", .3", .3", .3", .2", .2",	.2/.2", .2/1.2", .2/.2", .2/.2", .1/.1", .1/.1", .1/.1", .1/.1", .1/.1", .1/.1",	
2.	Lal Sagar. b. Plant (S)	.4", .4", .3", .3", .3", .3", .3", .3", .2", .2",	.2/.2", .2/ .2", .2/.2", .11/.1", .1/.1", .1/.1", .1/.1", .1/.1", .1/.1", .1/.1",	
3.	Chhitar Palace Tank. Young, green sporocarps. c. Plant (S)	·6", .6", '6", .6", .5", .5", .5", .5", .5", .5",	.2/.2", .2/.2", .2/.2", .2/.2", .2/.2", .2/.2", .2/.2", .2/.2", .2/.2", .2/.2",	

4.	Chhitar Palace	.5",	.5",	.2/.2",	.2/.2",	
	Tank.	.5",	.5",	.2/.2",	.2/.2",	
		.5",	.4",	.2/.2",	.2/.2",	
	d. Plant (S)	.4",	.4",	.2/.2",	.1/.1",	
		.4".	.4",	.1/.1",	.1/.1",	
5.	Chhitar Palace	.7",	·6",	.2/.2",	.2/.2",	
	Tank.	.6",	.6",	.2/.2",	.2/.2",	
		·6".	.5",	.2/.2",	.2/.2",	
	e. Plant (S)	.5",	.5",	.2/.2",	.2/.2",	
		.4",	.4",	.1/.1",	.1/.1",	

The study of external morphology which largely depends upon ecological factors shows that the growing parts such as tips of rhizome, petioles and young sporocarps are densely covered with hairs. These hairs are longer in size and consist of more numerous cells than those which are present on the older parts such as the ripe sporocarps. It is not uncommon to see that the average size of the individual cells of these hairs too is also bigger in those hairs found on the younger parts. This is indicated in the following table.

TABLE 6.

Number of cells on the Organs of *M. aegyptiaca* Willd.

S. No.	Organs.	Counts of hairs	Remarks.
1.	Apex of rhizome	10, 9, 8, 11, 11, 9, 9, 8, 12, 7, 10; 12, 11, 10, & 9. Average = 10.	
2.	Petiole	6, 5, 5, 4, 5, 3; 6, 4, 3, 5, 4, 5, 4, 3, 3. Average = 4· 4.	
3.	Leaf.	3, 4, 5, 5, 5, 3, 4, 3, 5, 5, 5, 4, 4, 3. Average = 4.	Distal pair more densely covered with hairs than the proximal pair of leaves.

4.	Young Sporocarp.	6, 3, 4, 6, 5, 7, 6, 3, 4, 3, 6, 5, 4, 6, 5, 4. Average=5.
5.	Old Sporocarp.	5, 4, 3, 5, 3, 4, 2, 1, 3, 4, 5, 2, 1, 5, 3. Average=3·3.

The above study seems very interesting. Further work on the nature and structure of these hairs together with the epidermal study of leaves is in hand. As indicated elsewhere these features might provide additional data for distinguishing the various species of *Marsilea* even on the vegetative grounds. And it is very important, for the vegetative plasticity of the genus is so variable.

Summary.

Marsilea aegyptiaca, a recently discovered species in India has been studied very briefly from the ecological standpoint. The morphological plasticity of the genus including that of the present species found in Jodhpur is clearly established on the data given in the present paper. It has been pointed out, however, that certain characters like the morphology of the hairs on the various organs of the plant might prove of systematic value in the future.

LITERATURE.

Allsopp, A. 1952. Experimental and Analytical studies of Pteridophytes XVII. The effect of various physiologically active substances on the development of *Marsilea*, in sterile culture. Ann. Bot., N. S. XVI, p. 165.

1953. a. Experimental and Analytical studies of Pteridophytes XIX. Investigations on *Marsilea*. 2. Induced reversion to juvenile stages. Ibid. XVII, p. 37.

1952. b. Longevity of *Marsilea sporocarps*. Nature, cL XIX, p. 79.

1952. c. 'Spiral' roots in Agar cultures of *Marsilea*. Ibid. p. 1019.

1953. Experimental and Analytical studies of Pteridophytes XX. 3. Investigations on *Marsilea* Ann. Bot., N. S., XVIII. p. 449.

Baker, J. G. 1887. 'Fern Allies', London.

Christensen, Carl 1906–34. "Index Filicum".

Gupta, K. M. 1955. On the occurrence of *M. aegyptiaca* Willd, in Jodhpur, Rajasthan (India). Journ. Bomb. Nat. Hist. Vol. 52.

Gupta, K. M. & Bhardwaj, T. N. 1955. On the investigation of Indian Marsileas: their morphology and systematics. 1. *M. aegyptiaca* Willd, with remarks on the systematic position of Indian species. Journ. Bomb. Nat. Hist. Vol. 53

Mahabale, T. S. & Gorgi, G. H. 1948. Some observations on the sporelings and adult plants of *Marsilea quadrifolia* Jour. Univ. Bombay, XVI, 27.

Acknowledgements.

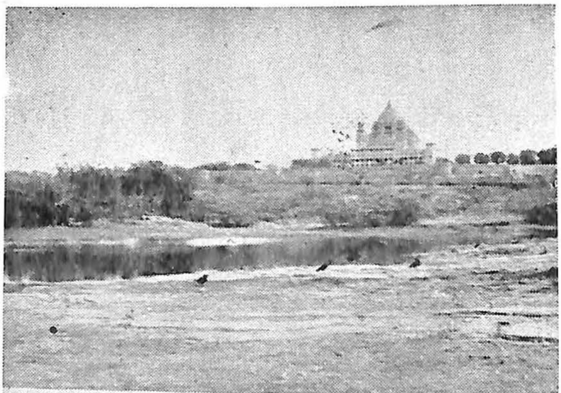
I wish to express my grateful thanks to Dr. K. M. Gupta. D. Sc., Head of the department for his guidance and help throughout this work.

Explanation of Plates I & II, figs. 1 – 7.

1. Localities where *Marsilea aegyptiaca* grows abundantly. Fig. 1, Chhitar Palace tank; fig. 2, embankment of the same tank; fig. 3, Lalsagar tank, another prolific locality for *Marsilea aegyptiaca* (see also fig. 6, Plate II).

2. Figs. 4 & 5. Photographs of the Herbarium sheets of *M. aegyptiaca* showing subterrestrial and aquatic plants respectively; fig. 6, Lalsagar tank where plants grow in abundance; fig. 7, Some plants in a flower pot. Plants in photos 4, 5, 7, reduced.

PLATE I



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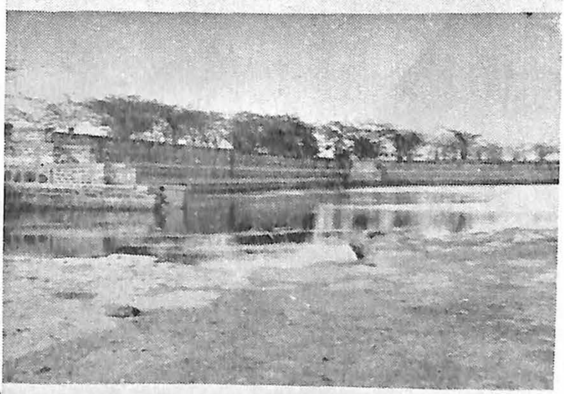

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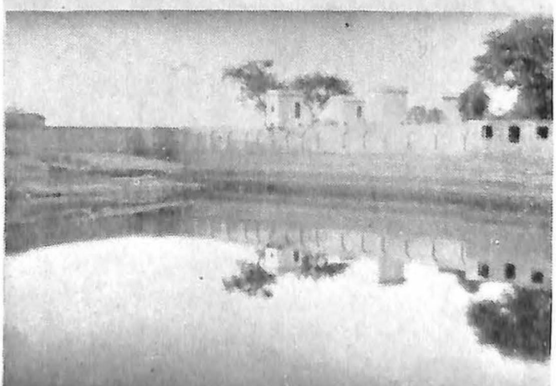

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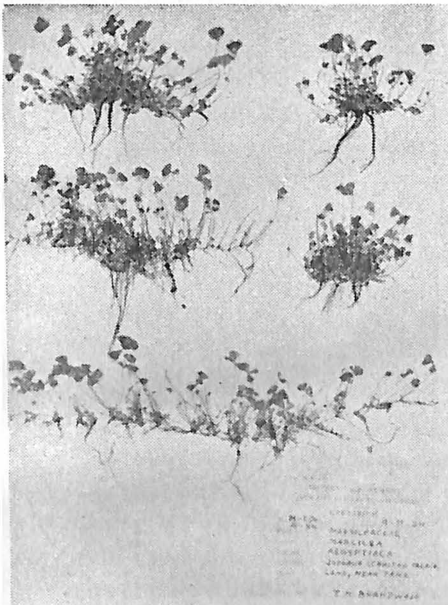
PLATE II



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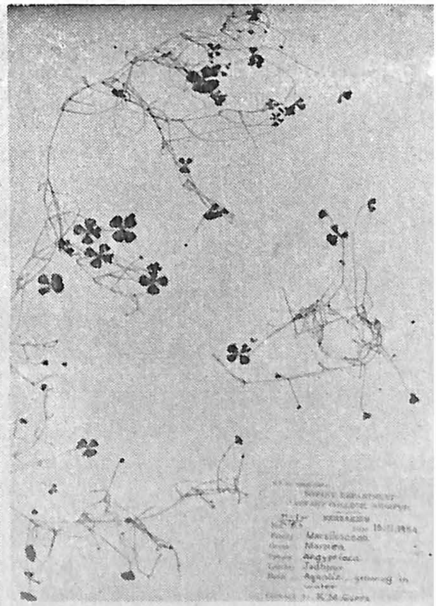

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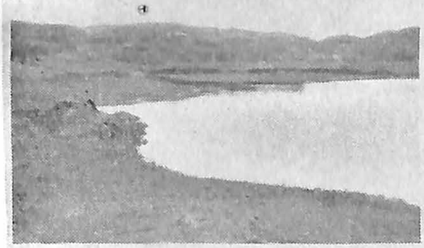

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7

Powdery Mildew of Wheat in Rajasthan

By

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Introduction.

The powdery mildew of wheat is caused by *Erysiphe graminis tritici* El. Marchal. The disease is widely prevalent and has been reported from practically all the important wheat-growing areas of the world. Mehta (1930) has reported its occurrence in U. P. in the Kamaun Hills, at the foot of the Himalayas and once from the low-lying areas of Allahabad. Arya and Ghemawat (1953) reported serious damages caused by the disease in the low-lying tracts of Jodhpur where the cultivation of wheat is practiced. The disease has also been observed occurring at Bharatpur.

The disease may cause heavy losses to the wheat crop (Tapke, 1951; and Arya and Ghemawat, 1953). Vik (1937) reported that the disease caused a heavier reduction in yield than any other disease of wheat crop in Norway. Newton and Cherewick (1947) have estimated the damage from the mildew to be as high as 87 percent.

INCIDENCE

The disease makes its appearance usually at the 'ear's peeping' stage. In countries with severe winters, the mildew develops abundantly during the early summer and continues through the autumn to early winter. Under Indian conditions, it appears very late in the last week of February to the first week of March and continues upto the harvesting of the crop in the month of April.

The mycelial growth is most vigorous at the maturity of the plant but the cleistothecia are generally formed in the early senile stage and their development is favoured by the delay in harvesting.

Arya and Ghemawat (1953) determined the crop and plant infections separately at different intervals during the wheat crop period; and the results, recorded in the table, show that the disease is not serious in the first week of its appearance but afterwards it spreads rapidly and takes up severe proportions.

TABLE 1.

Periodical Assessment of the Percentage of Crop and Plant Infections.

Date	Percentage of Crop Infection	Percentage of Plant Infection
10-3-52	28.7	5.3
25-3-52	61.3	18.1
9-4-52	86.1	23.8
24-4-52	97.4	26.2

A number of factors have been reported to govern the incidence of the mildew. External factors, particularly the climatic conditions, have been reported to have a profound effect on the appearance of the disease. Late-sowing, dense stands, extensive lodging and highly cultivated land, copiously supplied with fertilizers, specially nitrogenous, help to increase the severity of the disease. Arya and Ghemawat (1953) have observed high incidence of the wheat mildew in low-lying and moist areas.

SYMPTOMS AND EFFECTS

The mildew is characterised by loose whitish-brown patches of powdery appearance in the early stages. Later on, the patches turn moderately brown in colour. The patches are usually irregular and small in the beginning but may coalesce and cover large areas on the leaf-blades. The entire leaf-blade may be coated with mildew sometimes (Plate No. 1).

All the aerial parts of the plant give the usual symptoms. However, the first symptoms of infection appear on the upper surface of the leaf-blades. Later on, it becomes common on the lower surface of the lamina and leaf sheaths as well. In cases of severe attacks, even the stems and the floral bracts produce the powdery symptoms (Plate No. 2).

Late in the season, when the ears are at the milky stage, symptoms of the cleistothecial stage appear; amidst brownish patches, hyaline growth of the fungus, quite distinct from the usual colour of the patch, becomes very pronounced and black dot-like bodies of cleistothecia are produced. This stage usually appears first on the lower parts of the plant but later on may extend even to the ear-heads.

In the earlier stages of infection slight hypertrophies may be produced due to the stimulation of the host-tissue. At the later stages, the infected leaf turns brown, shrivels and may ultimately be killed. The plants become stunted at the face of severe infections. This may be due to a reduction in the number and size of the leaves. Moore (1944) has reported the formation of deaf ears and shrivelled grain as a result of heavy infection. Infected ears are usually smaller than the healthy ones and may be distorted if the attack is heavy. Awn production is frequently reduced or suppressed in bearded varieties*.

The heavily mildewed plants show a physiological disturbance and are more acidic. Several authors have studied the influence of the mildew on the metabolism of the host plant and it has been found that the fungus has a marked effect on the respiration, glycolysis and transpiration of the infected plant.

MORPHOLOGICAL CHARACTERS

The fungus is an ectoparasite. The mycelium is superficial and is attached to the host by lobed haustoria (Fig. 1). They penetrate the epidermis and lie in the epidermal cells; occasionally they are also found in the spongy tissue of the leaf.

The mycelium is hyaline to faint brown, septate and profusely branched. The mycelial hyphae can be distinguished only with difficulty from the reproductive parts (conidiophores). The hyphae are interwoven to form a web-like coating on the surface of the leaf. They vary in thickness from 2.9μ to 4.3μ with a mean of 3.5μ. Their cells measure in length from 13.0μ to 39.1μ with a mean of 26.5μ (Fig. 2).

Conidiophores are produced in abundance. During the development of a conidiophore, a hemispherical swelling appears at right-angles to the horizontal hypha. Later on, this develops into an erect conidiophore. Conidiophores are comparatively brown in

*Plant Disease Leaflet No. 32, Department of Agriculture, New South Wales, 1949.

colour and are more closely septate than the vegetative mycelium. They measure 116—187μ × 4.3—10.2μ with a mean of 151μ × 7.8μ (Fig.3).

Conidia are uninucleate and unicellular. They are hyaline in colour, elliptical in shape and are borne in chains. The chains consist of ten to eighteen conidia which are produced in a basipetal succession. The maturing conidia become barrel-shaped. They are produced in large numbers and have thin and smooth walls without any definite germ-pores. They readily fall off and are dispersed by wind. They measure 21.73—27.52μ × 8.69—11.59μ with a mean of 24.94μ × 9.73μ. (Fig. No. 3a).

Cleistothecia are globose, dark-coloured bodies, partly immersed in the mycelial weft. They are provided with simple, short, pale-brown appendages. The latter measure from 5.8—37.7μ × 2.9-5.8μ with a mean of 17.8μ × 4.9μ (Fig. 4). Cleistothecia measure 135–257*u* in diameter with a mean of 187*u*.

The release of cleistothecia from the host plant has been observed by the author to be favoured by wetting and by the disintegration of the intermixed mycelium on the older leaves.

The development of asci in cleistothecia in nature is quite frequent; the number of the former varying from 9 to 24 with a mean of 15 in each cleistocarp. The asci are hyaline and elliptical-oblong with a prominent pedicel which is usually bilobed. They measure from 61—107μ × 26—37μ with a mean of 82*u* × 32*u*. They contain abundant protoplasmic contents with prominent vacuoles (Fig. 5). Foster and Henry (1937), Gorlenko (1940) and Smith and Blair (1950) have observed the production of ascospores to be regular, but under Indian conditions, Mehta (1930) and Arya and Ghemawat (1953) have not recorded a single case where ascospores developed in nature.

PHYSIOLOGICAL STUDIES

Erysiphe graminis tritici El. Marchal is an obligate parasite and no artificial cultures of the fungus have been raised as yet.

Production of asci and ascospores in nature being infrequent, artificial means have been employed by some workers for producing them in the laboratory and the field. Arya and Ghemawat (1953) obtained positive results of ascospore-formation in the otherwise sterile cleistothecia with asci under different conditions of temperature and various concentrations of sucrose, nitric acid and potassium nitrate (Fig. 6, 7, 8 and 9).

Wolff has studied the germination of ascospores and their infection of a wheat leaf (Salmon, 1903).

Arya and Ghemawat (1953) have studied the germination of conidia under different conditions in detail. The results, obtained by them, show that the time required for the conidial germination is the least and the percentage of germination, together with the elongation of germ-tubes, highest (54 percent) at 100 percent relative humidity. However, the conidial germination is greatly handicapped in the actual drop of water. Another important observation made is that the germtubes assume an erect position in a drop of water which confirms the view expressed by Dickinson (1949). No germination was obtained below 92.9 percent relative humidity.

Arya and Ghemawat (1953) have found that the percentage of conidial germination is highest at 9°C while the length of germ-tube is greatest at 25°C. Thus though comparatively high temperature (25°C) appears to be the best for the mycelial growth, lower temperature of 9°C is more favourable for starting germination of the conidia. The fungus retains its viability upto 32°C.

PATHOLOGICAL STUDIES AND PHYSIOLOGIC SPECIALIZATION

Infection with the mildew cannot be obtained by artificial inoculations if the minimum and maximum temperatures of the day are higher than 76°F and 100°F respectively. Further, saturated humid condition for at least six hours is necessary for obtaining infection (Arya and Ghemawat, 1953).

The fungus, responsible for the powdery mildew on wheat, is highly specialized and it will not attack related host-plants such as barley and oats. The author has observed that the form sp. present on wheat does not attack barley plants growing even intermixed with wheat. Further, a number of physiologic forms of the fungus *Erysiphe graminis tritici* El. Marchal have been reported from different countries and a single variety of wheat may behave differently towards different physiologic forms. Mains (1933) has done a very important work in this field.

LIFE-CYCLE AND THE ANNUAL RECURRENCE

Bjorling (1946) has studied the cytology of the development of cleistothecia.

The fungus reproduces regularly by conidia and more or less irregularly by ascospores and the comparative importance of the two forms of spores in the annual recurrence of the disease is much debated.

In countries with severe winters, Foster and Henry (1937) found that the conidia are not concerned in the overwintering of the fungus but it is at the cleistothecial stage that the fungus overwinters. Ascospores are formed in spring at the outset of favourable conditions and just before the first infections of winter wheat are observed. Honecker (1936) confirms this view that the cleistothecia play an important role in the spread of the disease.

However, Gorlenko (1940) reports that the fungus overwinters on the lower leaves of the winter wheat in the form of dense brown mycelial mats which develop conidia, which in spring produce new pustules. The hardy ascigerous stage, according to him, does not constitute an important mode of overwintering of the fungus but provides a means for ensuring the infection of winter wheat in the late autumn.

Brooks (1928), Mehta (1930), Savulescu, Sandu-ville, Rayss and Alexandri (1935) and Arya and Ghemawat (1953) could not find any role of cleistothecia in the annual recurrence of the disease.

Further, Brooks (1928) and Savulescu, Sandu-ville, Rayss and Alexandri (1935) have found in England that conidia survive in the sheltered situations throughout winter.

Under Indian conditions, Mehta (1930) discussed the annual recurrence of the wheat mildew emphasizing the following points:--

1. On the foot of hills, on account of high temperatures, the fungus cannot survive in the oidial stage during the months of April to October in the absence of wheat crop.

2 The cleistothecial material, collected at the harvest time from fields in the hills and at the foot of the hills, has invariably been found to be sterile (without ascospores).

3. The infection is absent for about two months from the date of sowing at the foot of hills. This indicates that the cleistothecial material does not cause infection and is ineffective for propogation of the fungus.

4. The fungus has been found to survive on self-sown plants in the oidial stage at the hills during summer months.

Mehta concluded that the infection at the foot of hills and its casual appearance in the plains, under moist conditions of weather and soil, is probably wind-blown from the hills.

Arya and Ghemawat (1953) have also studied the annual recurrence of the fungus in detail and have made the following conclusions:–

1. Cleistothecia are sterile in nature at Jodhpur (Rajasthan) and even after subjecting them to different conditions analogous to those found in nature, no ascospore developed. Hence there remains practically no chance to suggest any positive role of cleistothecium in conditions of the locality mentioned.

2. The infection is wind-borne at Jodhpur and at the time of catching conidia on the exposed aeroscopic slides, the wind continued to be from North and North-East.

This suggests two possibilities, (i) that the Himalayas help in the oversummering of the conidial stage of the fungus or (ii) there might be some patch of low-lying land in the North and North-East of Jodhpur where the cleistothecia produced might be fertile (with ascospores) and serve as a source of initial infection there and conidia produced might be blown to infect the crop in the area under reference.

CONTROL

The following measures have been suggested for minimising and exterminating the wheat mildew:—

1. Eradication of self-sown plants and tillers of the previous crop, may be useful to control the disease (Mehta, 1930; and Smith and Blair, 1950)

2. A number of fertilizers, mineral salts and chemicals have been mixed with the soil and their effects on the mildew infection have been studied.

Potash, silicic acid, silicon dioxide, cadmium, manganese and esna lithium check the mildew infection to a certain extent.

3. Some fungicides, such as sulphur dust, lime sulphur, dithane Z-78, zinc sulphate and uspulun, have been used with more or less positive results to control the mildew.

4. The author recommends the use of early sowing varieties of wheat to ;eacape heavy damages from infection under North Indian conditions.

5. Little progress has been made in breeding wheat varieties resistant to the mildew and only a few resistant varieties of wheat have been developed.

It is recommended that more attention should be paid to develop resistant varieties of wheat.

REFERENCES

1. Arya, H. C. And Ghemawat, M. S. 1953 Occurrence of Powdery Mildew of Wheat in the neighbourhood of Jodhpur. Indian, Phytopath. VI, 2, pp. 123–130

2. Bjorling, K. 1946 Observations on the development of *Erysiphe graminis* DC Forh. fysiogr. Sallsk. Lund. XVI, 19 pp. 187–203 (Original not seen). R.A.M., XXVII, 1948, p. 128.

3. Brooks, F. T 1928 Plant Diseases. (Original not seen) After Mehta, 1930.

4 Dickinson, S. 1949 Studies in the physiology of obligate parasitism. 1. The stimuli determining the direction of growth of the germ-tubes of rust and mildew spores. Ann Bot., Lond., N.S., 13, 49, pp 89–104.

5. Foster, W. R. and Henry, A. W. 1937 Over-wintering of certain cereal pathogens in Alberta.

Canad. J. Res., Sect., C. XV, 12, pp. 547–559.

6. Gorlenko, M. V. 1940 Neue Befunde uber die Biologie von *Erysiphe graminis tritici* March.

(New results concerning the biology of *Erysiphe graminis tritici* March.)

C.R. Acad. Sci., U.R.S.S., N.S., XXVII, 8, pp. 866-870.

(Original not seen)

R A.M., XXI, 1942, pp. 191-192.

7. Honecker, L. 1936 Uber den derzeitigen Stand und die Aussichten der Bekamfung des Meltaubefalles der Gerste durch Zuchtung.

(On the present status and prospects of Barley mildew infection by breeding).

Prakt. Bl Pflanzenb., [illegible] 309–320.

(Original not seen).

R.A.M., XV, 1936, pp. 568-569.

8. Mains, E. B. 1933 Host specialization of *Erysiphe graminis tritici*.

Proc. Nat. Acad. Sci., XIX 1, pp. 49–53.

9. Mehta, K. C. 1930 Studies on the annual recurrence of "Powdery Mildews" of wheat and barley in India. I.

Agric. Journ. India, XXV, 4, pp. 283–285.

10. Moore, W. C. 1944 Cereal diseases in England and Wales. Ann. appl. Biol, xxxi, 4, pp. 360-362.

11. Newton, M. and Cherewick, W. J. 1947 *Erysiphe graminis* in Canada. Canad. J. Res., Sect. C, xxv, pp. 73-93.

12. Salmon, E. S. 1903 Infection powers of Ascospores in Erysiphaceae. J. Bot., xli, pp. 159–165.

13. Savulescu, T; Sandu-ville, C; Rayss, T. and Alexandri, V. 1935 L'etat phytosanitaive en Roumanie au cours de l'annee 1933-34. (Phytosanitary conditions in Rumania during the year 1933-34.). Inst Cerc Agron. al Romaniei, 24, 59 pp. (Original not seen). R. A. M., xv, 1936, p. 201.

14. Smith, H. C. and Blair, I. D. 1950 Wheat powdery mildew investigations. Ann. appl. Biol., 37, 4, pp. 570-583.

15. Tapke, V. F. 1951 Influence of preinoculation environment on the infection of barley and wheat by powdery mildew. Phytopath., 41, 7, pp. 622-632.

16. Vik, K. 1937 Melduggresistens hos Varhvete. (Mildew resistance in spring wheat). Medl. Norg. Landbertloisk., xvii, 7, pp. 435-495. (Original not seen). R. A. M., xvii, 1938, pp. 383-384.

Percentage of Crop and Plant Infections.

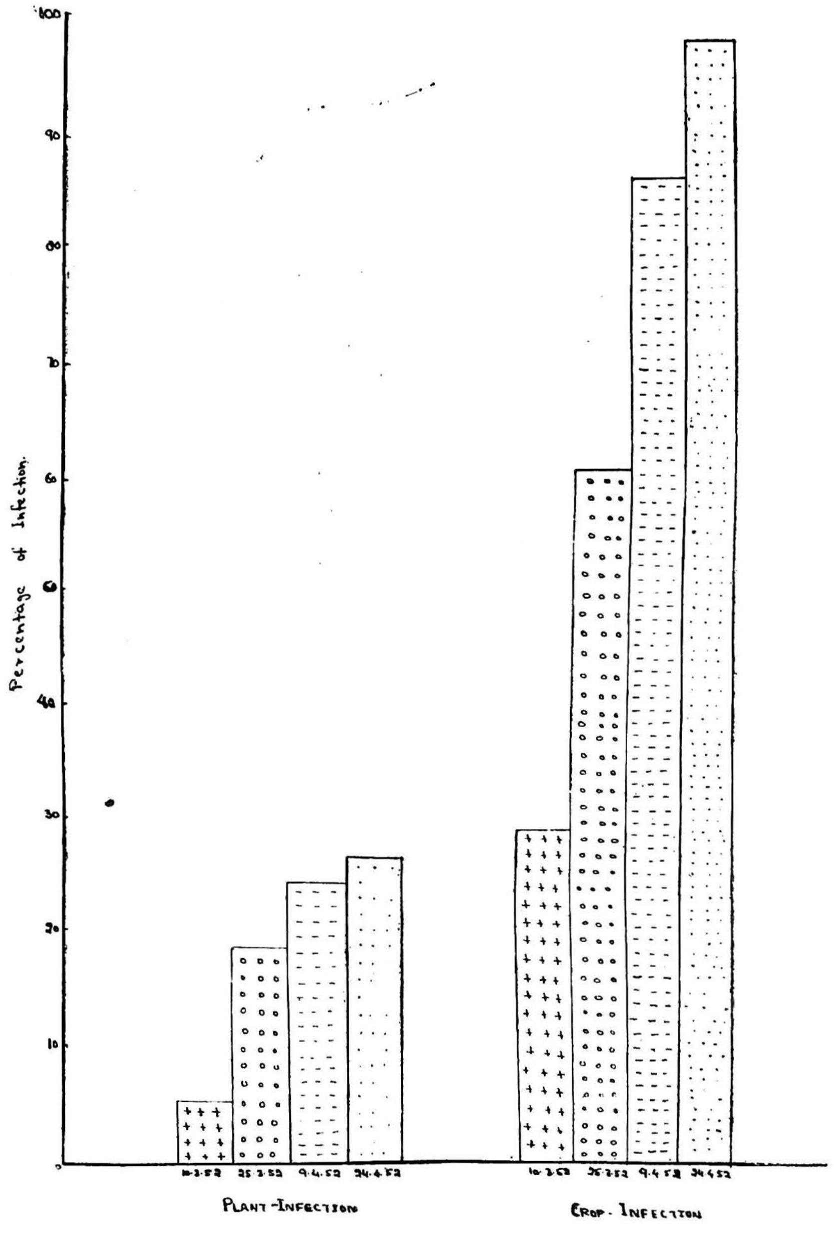
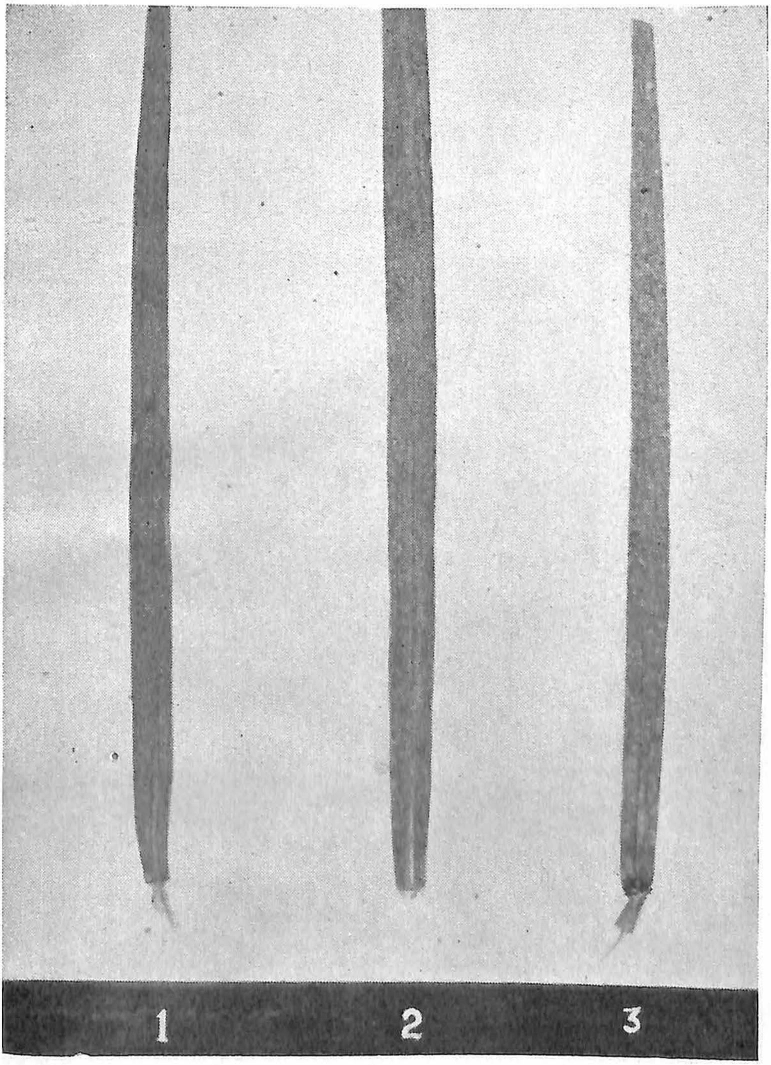
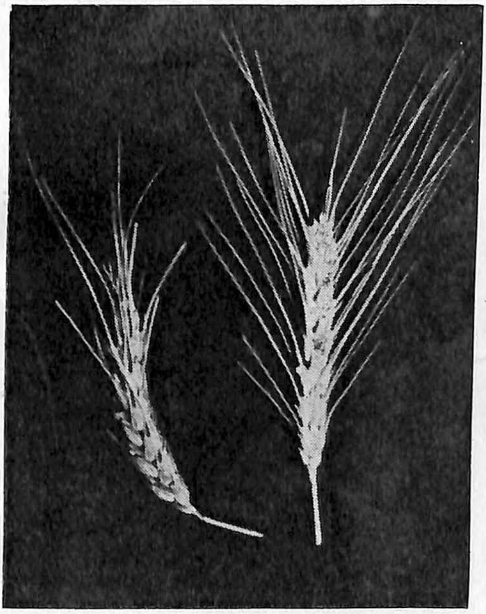


PLATE No. 1
Wheat-leaves.



Healthy   Slightly Mildewed   Heavily Mildewed

PLATE No. 2



Mildewed Ear. Healthy Ear.

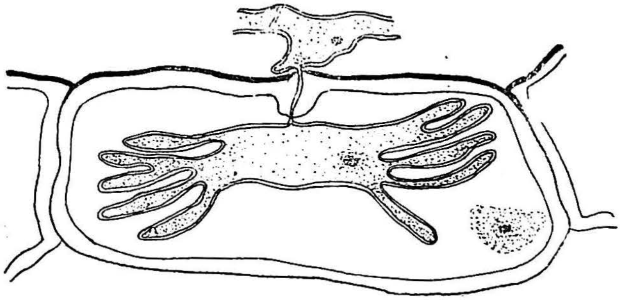
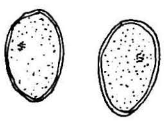


Fig. No 1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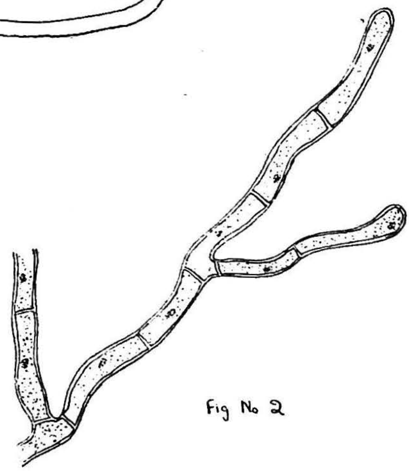
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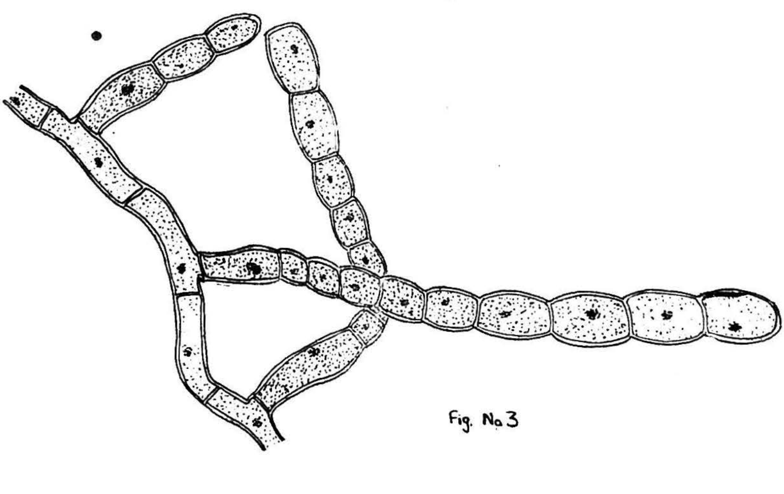
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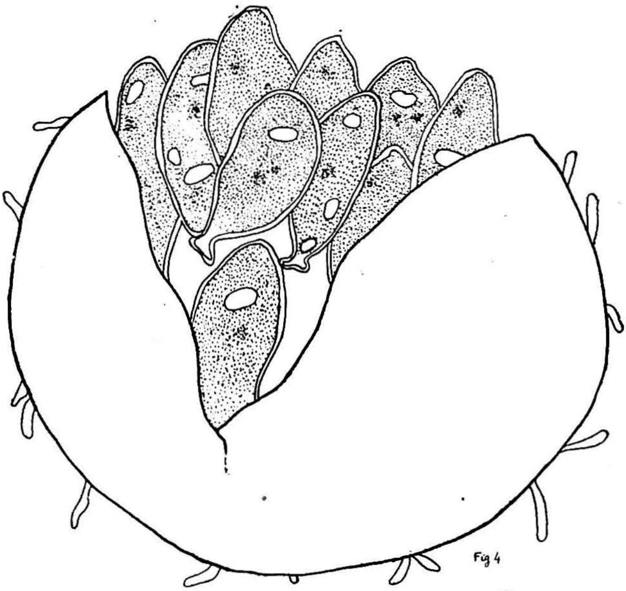

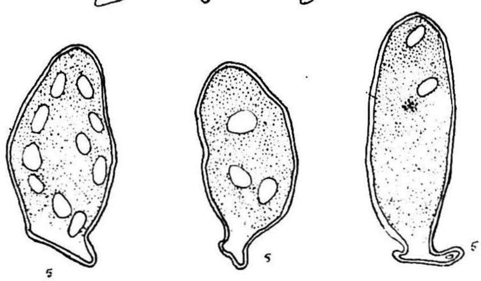

Fig. 4. Clestothecium ruptured to show asci.

Fig. 5. Asci with abundant protoplasm but without ascospores.

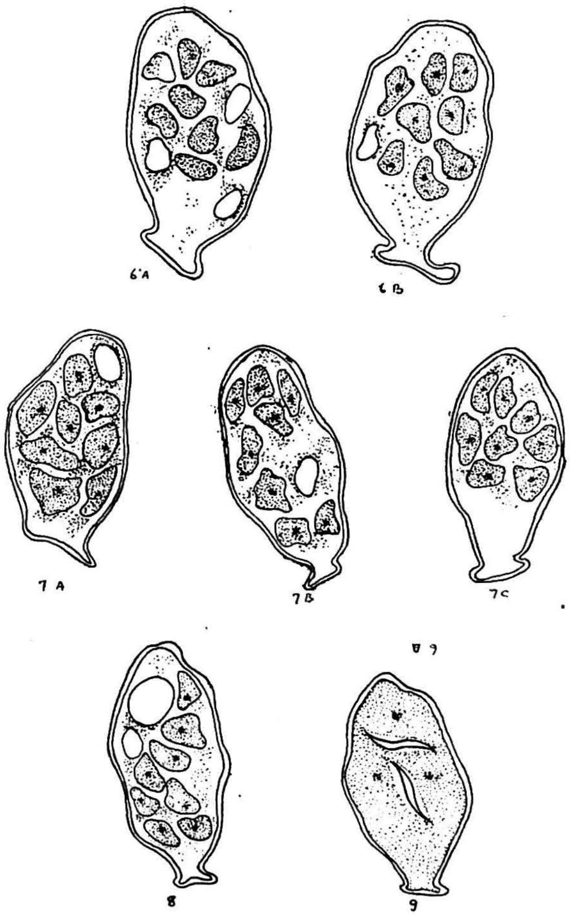

Fig. 6. Ascospore formation at different temperatures of freezing.
A. At 5°C
B. At 9°C

Fig. 7. Ascospore formation in sucrose solutions.
A. In 25% sucrose sol. after 17 hours.
B. In 10% sucrose sol. after 24 hours.
C. In 2% sucrose sol. after 120 hours.

Fig. 8. Ascospore formation in nitric acid concentrations. (8 drops of HNO_3 in 5 C. C. of water) after 144 hours.

Fig. 9. Cleavage formation in 25% Potassium nitrate solution after 168 hours.

*Chromosomes in the Spermetogenesis in two Common Pyrrhocorid Bugs (Heteroptera) From India.

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Acknowledgements.
Introduction.
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I t ke this opportunity of recording my grateful thanks to Dr. M. S. Mani, Professor of Zoology & Entomology, St. John's College, Agra, for guidance and all round facilities for work in the laboratory of School of Entomology. My thanks are also due to Mr. Santokh Singh, Research associate in the School of Entomology. I am also indebted to Mr. M. Bose, lectuier in Entomology for the identification of my specimens.

INTRODUCTION.

This paper summarizes the results of my studies on the nuclear changes and chromosomes during spermatogenesis in two common species of Pyrrhocorid bugs, *Odontopus varicornis* (Fabr.) and *Dysdercus cingulatus* (Fabr.) from India. The work was undertaken under the supervision of Dr. M. S. Mani in the laboratory of School of Entomology, St. John's College Agra.

Spermatogenesis in Heteroptera presents many special features and has engaged the attention of numerous workers. Although a

*Summary of thesis for M. Sc. in lieu of a paper, submitted at Agra University in 1954.

considerable amount of work has already been done on the chromosomes, their numbers, behaviour, and on the general course of spermatogenesis in Heteroptera, our kuowlcdge is still largely fragmentary. A useful survey of the work on the sex chromosomes and the general course of spermatogenesis in differeni families of the order Heteroptera upto the year 1922 was published in *Schroder's Handbuch der Entomologie.* Recently G. K. Manna*, and Ray-Choudhri and [1]Manna have studicd the chromosomes and the sex chromosomes in different families of Heteroptera and published some notes on the spermatogenesis.

MATERIAL & METHOD.

Over one hundred examples of nymphs and adults of the bug *Odontopus varicornis* (Fabr.), collected at Madras, were kept alive in cages in the laboratory on fresh twigs of *Hibiscus esculentus.* Nymphs and adults of *Dysdercus cingulatus* (Fabr.) collected at into the Botanical Gardens, St. John's College, were also maintained in cages during the whole course of investigations. The testes were taken out from freshly killed specimens of the bugs, dissected in normal saline, and fixed into the Zenker's fluid. After proper fixation the material was embedded in paraffin and in the usual way both longitudinal and transverse sections, 6μ thick, were cut in continuous serials and stained with the usual stains. Simple acid fuchsin however, gave the best results and clearly differentiated the chromosomes. Examinations of the sections were made under oil-immersion, using apochromatic compensating ocular combinations. The results were compared with observations under Reichert phase-contrast oil-immersion (Phase 1000). Estimates of the size of the chromosomes in the spermatogonial and spermatocytic metaphase equatorial plates were made according to simple graph paper method as described by Manna*. Drawings were made using phase-contrast attachment with camera lucida and the photomicrographs were taken with Leitz panphot.

THE TESTES.

The testes are paired structures in both *Odontopus varicornis* and *Dysdercus cingulatus.* In the former species, each testis is a pale coloured body consisting of seven follicles arranged in a row and opening into a common vas deferens In *D. cingulatus* the testes

*Proc. Zool. Soc. Bengal., 4:1-117, 1951.
1. Proc. 37, Indian Sci. congr. Abstr. 3:233. 1950.

are deep reddish-brown organs, each comprising of six follicles. In both the species each testicular follicle is enveloped by a *tunica propria* and each group is also likewise ensheathed by a *tunica adventitia.* The germ cells in the first and third follicles are somewhat larger than those in the fourth and the germ cells of the second follicle are perhaps the smallest. These differences in size are due to the total cytoplasm and volume of the nucleus, but is not in any way related to the number, size or behaviour of the chromosomes. The growth of the spermiocytes in follicles one to three are distinctly more pronounced than in the rest of the follicles.

The bright or often also deep reddish-brown colouration of the testes in *Dysdercus cingulatus* is due to the colouration of the outer connective tissue membranes, which are colourless in *Odontopus variconis*. Nearly all the stages of spermatogenesis can be found in the testes of bugs, immediateiy after the last nymphal moulting. In most cases all these stages occur within a single testicular follicle. The apical cells of the follicles are not, however, clearly differentiated in either of the species investigated.

SPERMATOGONIA.

The spermatogonia are few and isolated at first in the apex of the follicle, but soon give rise to rosette-shaped groups in which each spermatogonium is conical with its apex turned to the centre of the rosette. The resting nucleus of the two species differs from that of Orthopteriod types in the complete absence of the chromosomal zone and characteristc lobing. The total number of cell divisions of the spermatogonia appear to be eight, as estimated by the number of spermiocytes within a single cyst. The chromosomes differ in size on the metaphase equatorial plate and can be roughly arranged in a series of ascending size pairs. In any case the differences in size and shapes of the chromosomes are not so very well pronunced. The chromosomes are all tend to be globose or rod-shaped. The metaphase chromosomes are connected together in various ways by fine thread-like bridges The diploid chromosome number in *O. varicornis* is 8, and 16 in *D. cingulatus.*

SPERMIOCYTES.

In common with most other Heteroptera, beginning from the first maturation division, the following periods are recognized in the two bugs:—

(a) The presynaptic period.
(b) The contraction or the synaptic period.
(c) The diffuse period of chromosomes.
(d) the prophase of the first maturation division.

(a) The presynaptic period.

After the last spermatogonial telophase the chromatin material breaks up, and becomes distributed into a corse net work without differentiation of chromosomes (fig. 1). This is soon followed by a condensation of the chromatin granules into dense chromatin bodies, which are characteristic of the beginning of the spermiocytic period. Under favourable conditions, the diploid chromosome number is seen, but mostly we usually observe the irregular and close granules. Even at this phase, the heterochromosomes can readily be distinguished from the autosomes by their compact, non-granular, and darker appearance (fig. 2). The granular and irregular bodies now begin to change into closely twisted threads, which then transform into leptotene threads (fig.3). Although separate leptotene threads are formed, there is no continuous spireme (fig.4.) The number of leptotene is the autosomal diploid and the heterochromosomes retain their dense and smooth structure. It has not been possible to clearly decide whether the dense chromatin bodies merely elongate and then transform into the leptotene threads without spiralling at the same time. This phase is succeeded rapidly by further stretching of the leptotene threads with the result that obscure and delicate spiremes become visible (fig.4), although at no time continuous spireme threads are formed. The free ends of the chromosomes are often distinct. The leptotenes are always connected together by fine linin bridges. The sex chromosomes at this stage remain as deeply staining chromatin nucleoli, which are nearly rounded and much alike in the *Odontopus varicornis*. In the case of *Dysdercus cingulatus*, however, the diploid chromosomes being 16 and small, and apparently not quite differentiated from each other (fig.14). It is also not possible to clearly distinguish the heterochromosomes from the autosomes in the latter. In the former species the heterochromosomes are peripheral and lie usually in clear space outside the leptotene (fig. 4.).

(b) The contraction period.

During this phase of nuclear changes, the chromation threads change into dense masses, leaving clear gap around. The hetero-chromosomes usually lie outside the contracted chromatin material. This stage is frequently described as synapsis. It is during this contraction phase, which is characteristic of Heteropra, that conjugation of the chromosomes probably occurs. Although it has not been possible to directly observe the conjugation, this assmption seems to be justified by the fact that immediately after this phase we see the separation of the chromosomes in the haploid state. Aftei the contraction is over, the chromosome threads separate and the growth period of the spermiocytes begin.

(c) The period of diffuse chromosomes.

With the beginning of the growth phase, is initiated a considerable breaking up and redistribution of the chromatin material, so that the nucleus of the spermiocytes now has the appearance of the so called resting nucleus. This period of diffuse chromosomes is peculiar to the order Heteroptera and is clearly recognizable in both the species studied. The chromatin threads disintegrate into fine granules distributed on the net work of beaded threads (fig.5). The heterochromosomes, on the other hand, do not undergo this change, but remain entirely distinct (fig. 8.).

(d) Prophase of the first meiotc division (diakinesis).

The plasmosome or the true nucleolus, which was more or less distinct in the spermiocyte so far, now disintegrates. The chromosomes now strongly stain and increase in thickness. They seem to undergo uncoiling and stretching. The homologous members of the chromosomes lie side by side and the thickening of the autosomes is progressing, the tetrad figures arise. In both the species studied they are of the ring-type (figs.8&9). The automomes now transform into the characteristic shapes, peculiar to the spermiocytes of Heteroptera. All the autosomes are almost alike in size and shape and lack distinctive features.

FIRST MATURATION DIVISION.

The stout and bar-shaped chromosomes become orientated with their long axes parallel to the axis of the spindle (figs·10&11.)

When seen from the poles of the cells, we have the ring appearance of the chromosome arrangement, characteristic of true bugs (fig.9). The heterochromosomes lie near the centre of this ring. The contraction and swelling of the chromosomes progress so far that the transverse and longitudinal slits (fig 11), which were clear before, are no more visible. The mode of the formation of the tetrads, their orientation on the spindle, and the nature of the divisions are uncertain. In the anaphase the autosomes show a split at right angles to the division plane and each chromosome is connected by two spindle fibres (fig.12). The division of the heterochromosomes is equational.

INTERKINESIS.

After telophase the chromosomes approach each other but retain their individualities. Each chromosome is connected through a spindle fibre to the centriole of the corresponding side (fig.16). A distinct nuclear membrane is however not formed. The spindle fibres of the first maturation division actually persist into the second division.

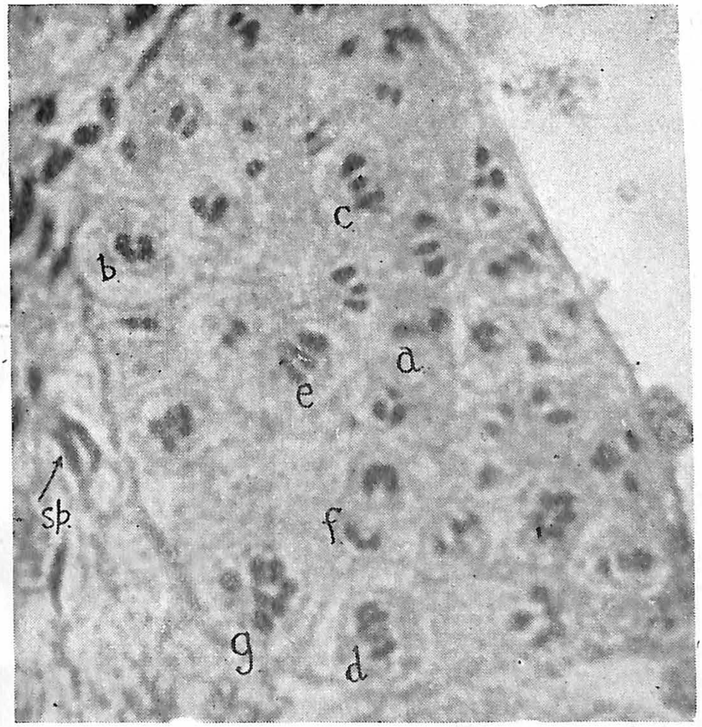
THE SECOND MATURATION DIVISION.

The arrangement of the chromosomes is here also in the form of a ring, with the heterochromosomes in the centre of the ring (fig.9). With the formation of the second maturation spindle, each chromosome turns round through 90.°, so that once more the autosomes lie parallel to the spindle axis. The spindle as a whole, however, now lies at right angles to the plane of the first maturation division. The autosomes divide transversely in the anaphase, so that we may infer that in the first division they had already halved, but remained united as partners. The second maturation division, therefore, seems to be reductional. The heterochromosomes remain undivided at the poles of the cells.

HETEROCHROMOSOMES.

The heterochromosomes of *Odontopus varicornis* comprise the typical paired and unequal idiochromosomes of *XY-type*. The haploid number of chromosomes is 4, in which Y-chromosome is the smallest. With the separation of the autosomes the heterochromosomes become distinct, until in the late metaphase the heterochromosomes come to lie in the centre of the ring of the autosomes on the equatorial plate.

In the case of *Dysdercus cingulatus,* the diploid number is 16 (fig.16) and the haploid chromosomes are 8 The heterochromosomes are also of *XY-type.* In the earlier stages, however, the heterochromosomes are not distinguishable from the autosomes being of comparatively smaller size than those of *O.varicornis.*



Photomicrograph of a T. S. testis of *Odontopus varicornis,* to show the various stages of the first and the second maturation divisions.

a—Beginning of the leptotene stage of the first maturation divisions.

b—Condensation of the Chromosomes during leptotene.

c—Leptotene stage.

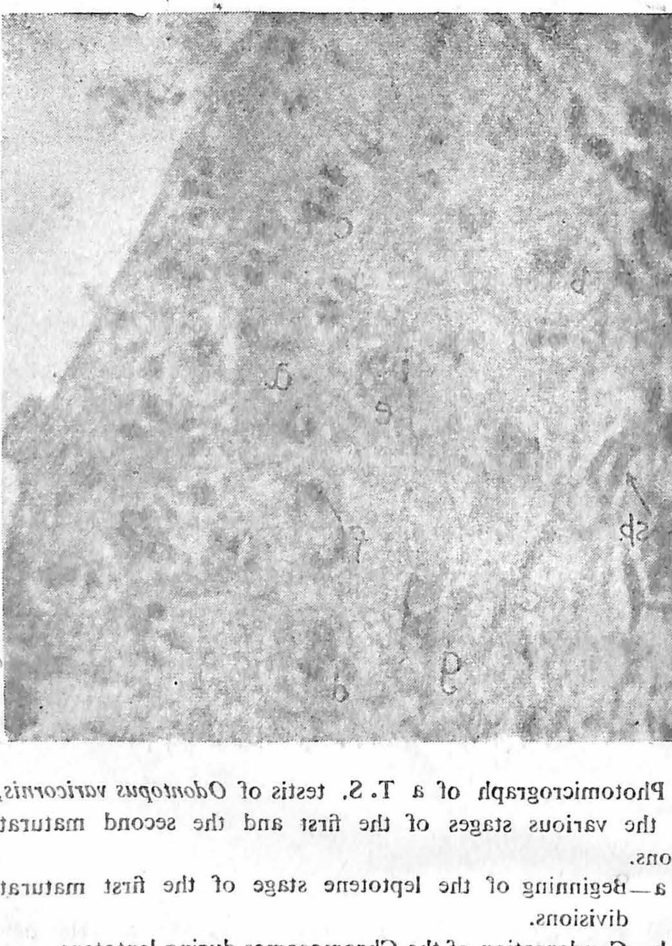
d—Beginning of the prophase of first maturation division.

e—Prophase of the first maturation division. The hetero-chromosomes separate out as a dark condensed body.

f—Anaphase of the first maturation division.

g—Ring type arrangement of the chromosomes.

sp.—Sperms.



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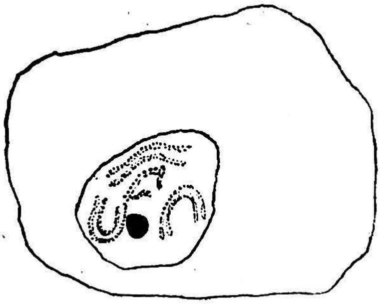

Fig. 1. *Odontopus varicornis.* Pre-synaptic period. Heterochromosome is seen as a dark and compact structure.

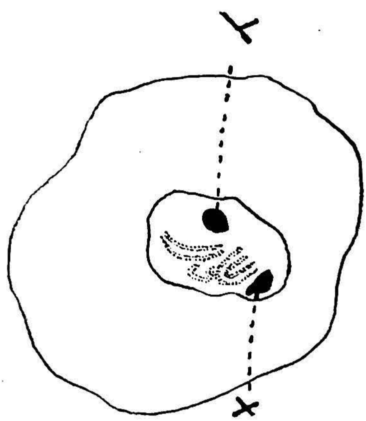

Fig. 2. *Odontopus varicornis.* Pre-synaptic period The heterochromosomes X & Y are distinguished from the chromatin granules as dark condensed bodies.

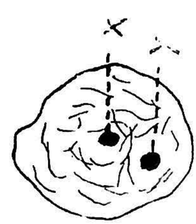

Fig. 3. *Odontopus varicornis.* Beginning of the leptotene stage of the first maturation division. X & Y are the heterochromosomes.

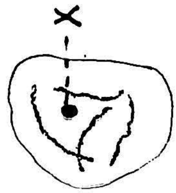

Fig. 4. *Odontopus varicornis.* Pre-synaptic period. Pachytene stage. X-Heterochromosome.

Fig. 5.

Fig. 6.

Fig. 5. *Odontopus varicornis.* Beginning of the prophase of the first maturation division. X & Y are the heterochromosomes.

Fig. 6. *Odontopus varicornis.* Prophase of the first maturation division. The heterochromosomes, X & Y are present as elongated rod-shaped structures. 1–6 represents the autosomes.

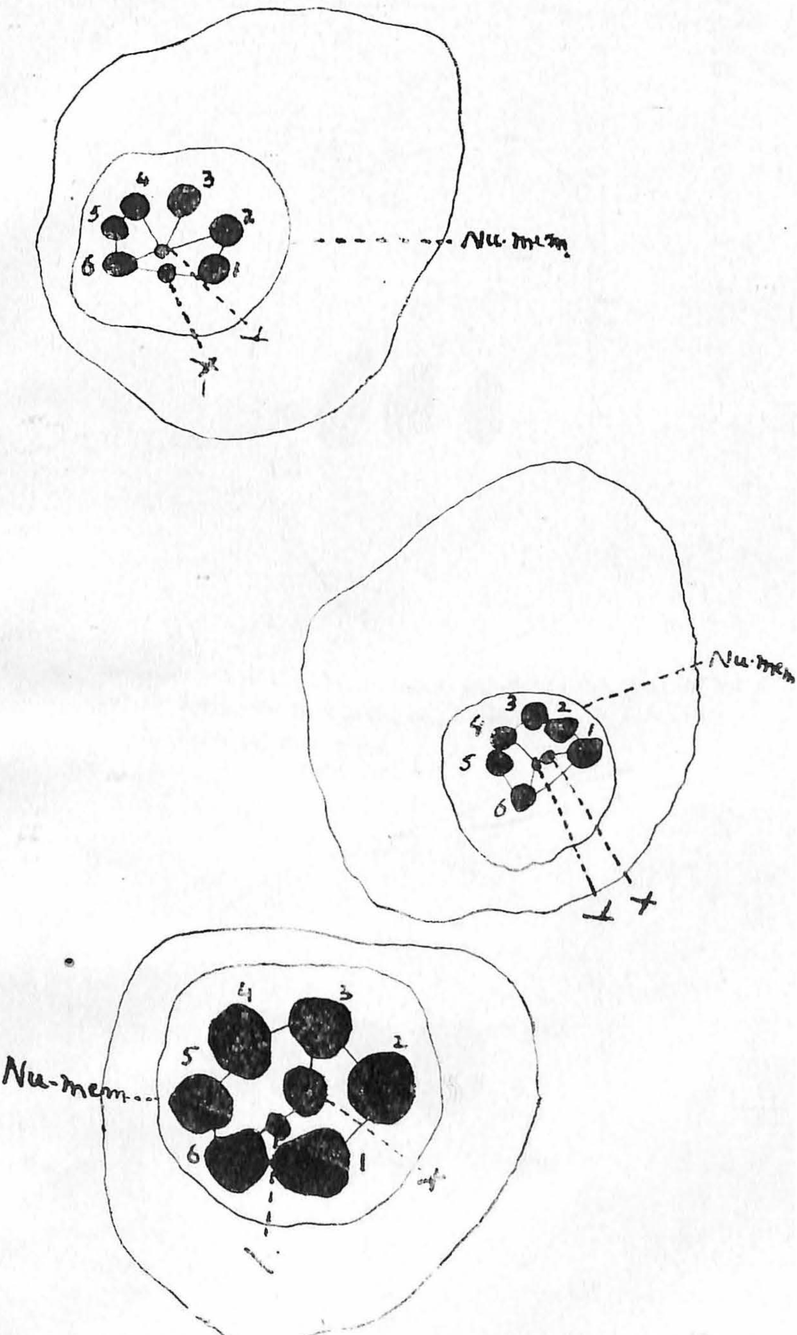

Fig. 7, 8, & 9. *Odontopus varicornis*. **Polar view of the metaphase plate showing the ring type arrangement of the autosomes (1-6) with heterochromosomes (X & Y) in the centre of the ring.**

Fig. 8 & 9 show the enlarged views of the same in different follicles.

Nu.–mem.–Nuclear membrane.

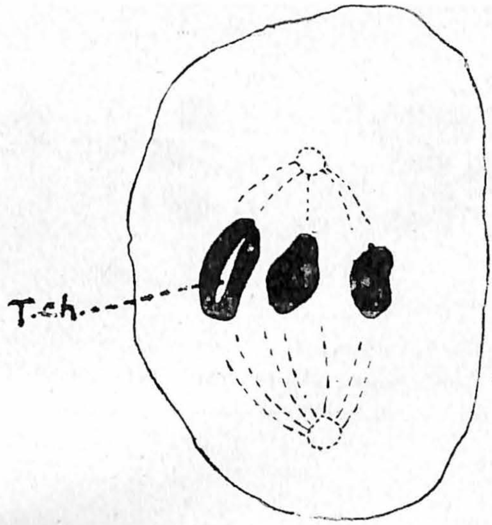

Fig. 10. Arrangement of the chromosomes parallel to the axis of the spindle during the first maturation division, in *O. varicornis*. T. ch.–Terminal chiasmata.

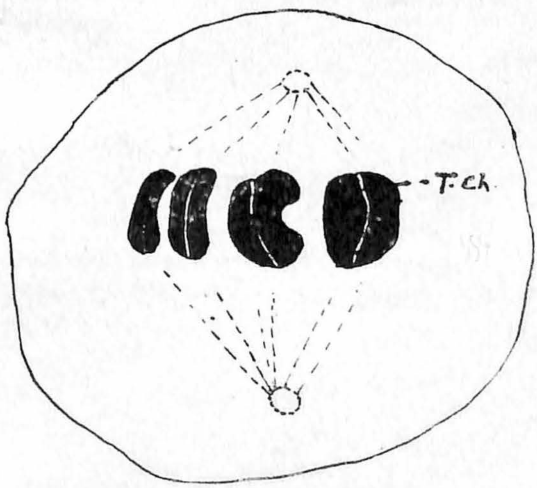

Fig. 11. *Odontopus varicornis.* **Arrangement of the chromosomes parallel to the spindle axis. The chromosomes have splitted up by the terminal chiasmata (T. ch.). The tetrad halves are connected by linin threads.**

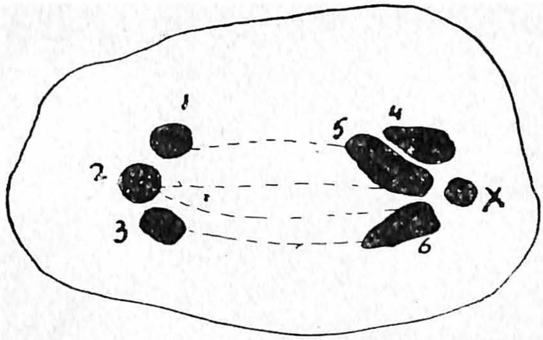

Fig. 12. *Odontopus varicornis* Anaphase of the first maturation division. 1–6 represent the autosomes. The heterochromosome (X) connected by simple fibres with the autosomes.

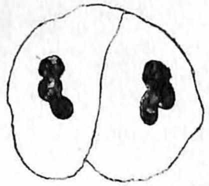

Fig. 13. *Odontopus varicornis*. First Spermiocytic division. Late telophase.

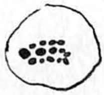

Fig. 14

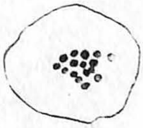

Fig. 15

Fig. 14. *Dysdercus cingulatus*. Leptotene stage.
Fig. 15. *Dysdercus cingulatus*. Late leptotene. Chromosome number is 16.

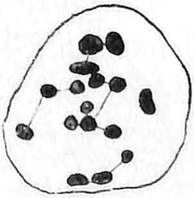

Fig. 16. *Dysdercus cingulatus*. Interkinesis.