KEYS FOR IDENTIFICATION OF PLANT REMAINS IN FAECAL MATTER OF UNGULATES

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Introduction

The keys for identification of plant remains in the faecal matter of ungulates have been prepared with reference to Chila Sanctuary (now in Rajaji National Park), situated at a distance of about 8 km, South and South-East of Hardwar in U.P., the study area (248.932 km^2 in area). Various species of wild ungulates found in the study area are Chital, Sambar, Barking Deer, Nilgai and Goral. These wild ungulates feed upon various plant parts present within their reach. Besides, following natural and biotic influence in the area bring down various plant materials which are otherwise unavailable and make them available within the approach of these animals.

(i) Natural dropping of deciduous leaves and mature fruits of trees.

(ii) Lopping (by Gujjars) of fodder tree species.

(iii) Elephant damage to trees belonging to various species, most important of which is *Mallotus philippensis*. Extent of damage varies from merely breaking of branches to uprooting of trees.

Studies in plant anatomy have taken long strides following the development of sophisticated microscopic techniques but much anatomical studies to put into use for identification of plant remains in animal droppings have not been done. Such a work in India is of recent origin. A beginning in this direction has been made by Satakopan (1972) to assist the Bombay Natural History Society in their long term project on ecological research in Gir Forest in collaboration with Smithsonian Institute and Yale University School of Forestry.

In the present work the methodology adopted and the criteria used in the preparation of keys are the same as used by Satakopan (1972). But the present work differs from that of her in the basis on which keys have been built. She built her keys on the basis of plant debris seen in the pellet samples, whereas in this work after having selected the workable criteria, the keys have been finally based on the study of are vegetative powders using those criteria, although the characterics as they are seen in the pellet samples have been simultaneously compared with those seen in the pure vegetative powders in most of the cases.

The studies presented in this work will also improve the knowledge of all those interested in the domain of plant Anatomy, besides serving the purpose for which they have been intended.

Materials

The materials were collected and preserved as follows from the study area in

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the months of November and December.

(1) About 70 species of plants consisting of twigs, leaves, flowers and fruits.

As far as possible, the same plant material possessing different parts such as twigs, leaves, flowers fruits was collected. In some cases detached leaves and fruits were also collected.

Twigs, leaves, flowers and small fruits were pressed, dried and stored in the form of herbarium for further study. Detached leaves were also pressed and mounted on herbarium sheets. Detached fruits and larger fruits were separately dried and kept.

(2) 35 samples of relatively fresh pellets of various ungulate species met within the study area. The collection of the pellet samples and plant material were done simultaneously.

The pellet samples were thoroughly dried for five days. Every day the samples were put in sunlight at 0900 hrs and were transferred to shade at 1600 hrs. One pellet then the samples were kept in polythene bags.

Methods

The methods have been mainly based on those adopted by Satakopan (1972) with minor procedural modifications.

(1) Preparation of slides from pellets, of various ungulate species, collected from study area.

These slides were prepared by processing each sample as follows :

(a) *Starting sample* : Each original sample contained more than 5 butless than 25 pellets. This sample was put in a dry tray, rolled and tossed in all directions till the pellets were thoroughly mixed; the sample was mixed and individual pellets were picked up from various portions till about six or eight pellets are obtained.

(b) *Preparation of final sample* : The starting sample was put in a mortar and ground loosely so that pellets discrete particles in a coarse powder form. The grinding was done to separate the agglomerates into single particles. The powder was then sieved through an ordinary sieve. The bigger particles that could not pass through the sieve were kept separately and finer particles were first taken for further processing. Those finer particles were further divided into four parts, only one of these parts was taken to constitute final sample; other three part were kept as reserve. Few pieces of bigger particles were taken and these formed a different final sample for the same pellet sample and the rest of these bigger particles were kept as reserve.

(c) *Further processing of final sample and preparation of slides* : The final sample were boiled in about 2 or 3 ml of chloral hydrate aqueous solution (50 g in ml) taken in a test tube using spirit lamp. If the chloral hydrate was too dark or coloured blackish, the powder was allowed to settle, supernatant poured off and fresh quantity of chloral hydrate was added and boiling repeated. In some case third boiling was found to be necessary. When the powder appeared to the eye as fairly clarified, the cooking was considered sufficient. After cooling distilled was added and the material was shaken thoroughly, allowed to settle and supernatant poured off. This washing was repeated till all the chloral hydrate was

washed off. The powder was than dehydrated with alcohol washings. These washings were repeated two or three times to remove all water. Thereafter, the powder was passed through grades of alcohol:Xylol mixtures with the latter in increasing proportion, in successive mixtures (Alcohol : Xylol 3 : 1, 1 : 1, 1 : 3) and finally in pure Xylol. The mounting was done in glycerine and thus temporary slides were prepared for study.

(2) *Preparation of slides from known plant materials* : In most of the cases permanent slides were prepared for study and future references from known plant materials. In some cases temporary slides were prepared for study. The slides were prepared as under:

A few bits of leaves, twigs, flowers and fruits and seeds were taken from each plant species. Every plant part was separately processed as under and a separate slide was prepared for each.

The bits of leaves and twigs were shredded coarsely and placed in a test tube. 2 or 3 ml of chloral hydrate aqueous solution prepared as above was added to the material in the test tube. The tube was heated on a spirit lamp, till boiling. Highly coloured materials took a second boiling with fresh quantities of chloral hydrate. The tube was allowed to cool, the liquid drained off, washed repeatedly in distilled water, dehydrated in alcohol, passed through grades of alcohol; xylol mixtures with latter in increasing proportion, in successive mixtures, (Alcohol : Xylol, 3 : 1, 1 : 1, 1 : 3) and finally, in pure xylol. The mounting was done in Canada balsam for preparing permanent slides. Some temporary slides were prepared using glycerine.

The bits of flowers, fruits and seeds were also processed in the same manner as above but 5% solution of KOH, instead of chloral hydrate aqueous solution was used in the initial treatment.

Preparation of Keys

Criteria used : To arrive at a basis on which to develop a key for the purpose, mounts prepared by author from pellets were studied in detail and characteristics so observed were compared with the characteristics seen in the slides prepared from pure vegetative tissue. This study which constituted the most important and most difficult part of the job, revealed that the characteristics which can be used as criteria for developing such keys must fulfill the following three requirements :

(i) The characteristic must come out with the faeces undigested, in the least altered or unaltered condition.

(ii) It should be constantly found in the genus or species concerned.

(iii) The characteristic must be specific to the species or at least to genus. These requirements have finally been fulfilled by structure, dimension and abundance of trichomes on which the main key has been based. For cross checking of the main key, supplementary keys have been based on certain other features of these plants that are present in the faecal samples. These features are crystals, epidermal cell characteristics, stomatal characteristics, sclereids, structural peculiarities in fruit and seed tissues.

Other microscopic characteristics of plant that are normally present in pure vegetative powders and serve for diagnosis are fibres, quantitative indices like number

of ray cell tiers, palisade ratio, veinlets number, epidermal cells per unit area, stomatal number etc. but these characters provide very little assistance in identifying the plant remains in pellets as they are unable to fulfill on or the other of three requirements mentioned above. Tissues and tissue systems loose their identity due to their disintegration and for the same reasons, they also do not occupy important position for their use in the preparation of keys.

Several species of grasses met with in the area were studied in detail and compared with plant remains in the pellets but no character has been found to fulfill all the three requirements as above. But the grass as a group can be identified very easily by structure of trichome or bits of leaf epidermis. Therefore no attempt has been made to prepare the key for the identification of grass species. The only attempt which has been made is to distinguish grass groups from Dicots.

The Keys

The various keys which have been prepared are described as under :

1. Key based on intact trichomes

Trichomes unbranched :

I A - Trichomes unicellular

(1) Trichomes curved, short, tip blunt, lumen narrow, but broader at the base, like an inverted funnel, a round crystolith sometimes present at the base of the trichome. Length varies from 140-385 microns, maximum width - 50 microns.

.....*Diospyros montana*

(2) Trichomes small, length 420-630 microns, maximum width 20 microns, curved, thick walled, narrow lumen, absent in older parts, present only on very young buds.

.....*Lagerstroemia parviflora*

(3) Over 510 microns in length, conical partition at the base. Very thick walled and very narrow lumen, sometimes absent; gradually tapering towards the tip, often curved.

.....*Anogeissus latifolia*

(4) Length 490-700 microns, maximum width 14 microns, thick walled, lumen narrow, but present upto the tip, present on veins and veinlets, base rounded.

.....*Milletia auriculata*

(5) Length 105-525 microns, width upto 30 microns, occurs singly, more abundant on pedicle and midrib, tip acute, lumen not present throughout the length of trichome, present only in proximal half or slightly more than half length. Lumen as broad as the cell wall whenever present.

.....*Lantana camera*

(6) Dimorphic, micro and macro types : (a) Micro types 35-140 microns, width upto 7 microns, always in congested groups. Sometimes curved in a hooklike manner, abundant, hyaline, thick walled narrow lumen. (b) Macrotypes - 150-280 microns, width upto 20 microns, spinous, sparse, thick walled, narrow lumen.

..... *Mallotus philippensis*

(7) Length 150-670 microns, maximum width 42 microns fusiform, thin walled, hyaline, abundant on young shoots, sparse on leaves.

..... *Indigofera onneaphylla*

(8) Length 105-840 microns, max. width 21 microns, abundant on leaf margin and on veins, base clavate, lumen narrow about 1/3 of the total width.

..... *Desmodium pulchellum*

(9) Length 140-350 microns, width upto 14 microns, very rare on leaves, cylinder, tip blunt; lumen narrow filled with fat blackish substance, appears as a black line along the length of trichome.

..... *Flemingia chappar*

(10) Length 70-560 microns, max. width 21 microns, abundant on leaf, generally curved or whipy, cell wall thin, lumen broad, tip acute.

.... *Flacourtia cataphracta*

(11) Length varies upto 770 microns, max. width 14 microns, ephemeral, abundant on flowers, young shoots and petiole, generally absent on mature leaves, very very rare on young leaves, lumen vary narrow, ascaroid.

..... *Shorea robusta*

(12) Length upto 160 microns, max. width 14 microns, tip obtuse, smooth, thin walled, broad lumen, vary rare.

..... *Aegle marmelos*

(13) Length 140-420 microns, max. width 14 microns, thin walled, lumen broad, tip pointed, abundant on petiole, straight.

..... *Delbergia sissoo*

(14) Length 280-770 microns max. width 56 microns, thin walled, broad, lumen, tip acute.

..... *Polygonum* spp.

(15) Length 49-175 microns, max. width 10 microns, thin walled, lumen broad, blunt tip, rodlike.

..... *Terminalia chebula*

(16) Length 500 microns or less max. width 25 microns, lumen as broad as cell wall but broader than cell wall at the base, slightly warty cuticle.

..... *Acacia* spp.

(17) Length upto 300 microns, stout, very thick, striated lignified walls with yellowish tinge, spinous or prickly.

..... Any grass

(18) Length upto 200 microns, max. width 10 microns, rounded base blunt tip, thin cell wall broad lumen.

..... *Schleichera oleosa*

I B - **Trichomes Multicellular**

I B 1. *Uniseriate, Pseudo-septate* :

(1) Length upto 490 microns, max. width 35 microns, always in conjested groups on the epidermal layer, 1-3 septate cell wall not very thick, lumen broader than cell wall upto tip, often curved.

..... *Woodfordia fruticosa*

(2) Upto over 700 microns, highly curved to coiled, spiral, whipy but never straight, septa more than two.

..... *Zizyphus mauritiana*

(3) Length 84 to 740 microns, max. width 28 microns, 3 to many celled, gradually tapering towards the tip, tip acute, smooth, lumen broad, cell wall thin.

..... *Zizyphus oenoplia*

(4) Length 70 to 770 microns, max. width (near middle part) 30 microns, fusiform, 3-septate, tip often curved, broad lumen, cell wall thin, absent on leaves, present on young shoots.

..... *Ichnocarpus* spp.

(5) Length 105-175 microns, max. width 14 microns, very rare, straight, spinous, many septate, lumen narrow, cell wall thick.
..... *Holarrhena antidysenterica*

(6) Length 70-320 microns, max. width 56 microns, two-nine celled, thick walled, lumen 1/3 of total width, spinous, wall warty, lowest cell with rounded base, not abundant nor very rare.
..... *Rungia repens*

(7) Length 350-420 microns, max. width 35 microns, 2-7 celled, lumen broad, progressive increase in cell-length from base to tip, tip acute.
..... *Ageratum conyzoides*

(8) Length 70-224 microns, max. width 21 microns, 2-5 septate, commonly three septate, thin walled, sometimes curved, sometimes with transverse striations.
..... *Bridelia retusa*

(9) Length 35-235 microns, max. width 14 microns, upto 3 - septate, tip blunt, lumen narrow, cell wall thin, often bow shaped, absent on leaves abundant on young shoots.
..... *Putranjiva roxburghii*

(10) Length 560-700 microns, max. width 43 microns, more than two-celled, lumen broad, cell wall thin. 2-3 proximal cells form bottle shaped structure, distal part gradually tapering to a pointed tip.
..... *Adina cordifolia*

(11) Length 56-560 microns, max. width 21 microns fusiform, sometimes spirally twisted, rarely with constrictions and swellings alternately along the longitudinal plane, lumen broad, thin walled, slender.
..... *Albizia procera*

(12) Length 56-70 microns, maximum width 35 microns, not very abundant on leaf, 2-5 septate, almost of the same width-along the whole length except near the tip where it gets narrowed down to a pointed tip, cell wall thin, broad lumen.
..... *Cassia tora.*

(13) Length 70-210 microns, max. width 14 microns, 3-celled, two basal cells almost rectangular and terminal cell is triangular.
..... *Limonia crenulata*

(14) Length 140-280 microns, max. width 21 microns, 2-3 celled very rare on leaves, tusk like, lumen broad cell wall thin.
..... *Murraya paniculata*

(15) Length 300 microns or less max. width upto 25 microns generally 2- septate, cuticle warty, lumen broader than wall, tips blunt, sometimes rounded.
..... *Bauhinia* Spp.

I B 2. *Uniseriate, true - septate.*

IB2 (a) Two celled :

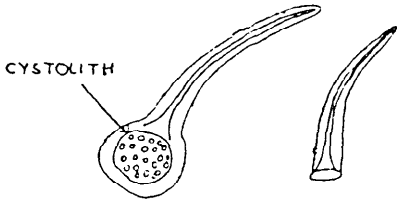
(1) Length upto 175 microns, very rare max. width 14 microns, 2 celled, thin walled lumen broad, proximal cell smaller about 1/3 of entire length distal cell longer narrow and triangular.
..... *Adhatoda vasica*

(2) Length over 500 microns, width 21 microns, smaller and broader basal cell and longer apical cell acute tip.
..... *Terminalia bellerica*

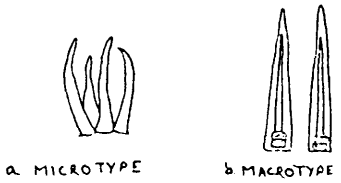
IB2 (b) More than two-celled :

(1) Length 154-525 microns, max. width 56 microns, 3-celled, basal cell smallest, node between middle and distal cell swollen, distal cell with closely serrated cell wall, tip acute,

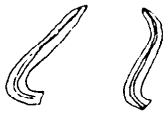
Trichomes of Different Plant Species



Diospyros montana

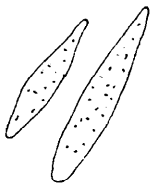


Mallotus philippinensis

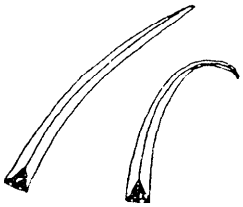


Lagerstroemia parviflora

Acacia sp.

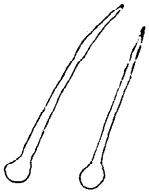


Indigofera onneaphylla

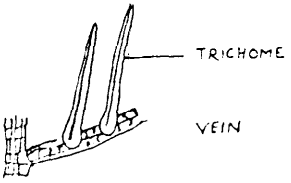


Anogeissus latifolia

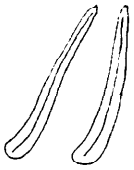
Schleichera oleosa



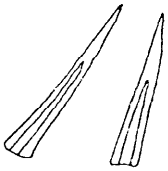
Desmodium pulchellum



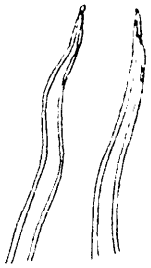
Milletia auriculata



Flemingia chappar



Lantana camara



Flacourtia sp.

lumen broad, cell wall thin.

..... *Achyranthes - aspera*

(2) Length 210-245 microns, max. width 14 microns, sparsely distributed singly, 2-4 celled, cell wall thick, lumen slightly broader than cell wall, distal cell longest and pointed.

..... *Vitex nigundo*

(3) Length 105-525 microns, max. width 56 microns, 2-3 celled, apical cell triangular, middle cell bottleneck shaped and proximal cell rounded (when trichome is 3-celled), in case of two celled trichome basal cell rounded and apical cell is triangular. In all cases basal cell is hyaline. Lumen broad cell wall thin.

..... *Xanthium strumarium*

(4) Length 210-770 microns, max. width 56 micros, 2-4 celled, base of all the cells swollen, apical cell abruptly narrowed to a pointed tip, lumen broad, cell wall thin.

..... *Tridax procumbens*

(5) Length 140-1300 microns, max. width 49 microns, 3-12 celled, progressive increase in length and decrease in width of cells from base upwards, apical cell pointed, lumen narrow, cell wall thick.

..... *Euphorbia hirta*

(6) Abundantly distributed, length 140-1540 microns, max. width 35 microns, 2-9 celled, basal cell clavate, lumen very narrow from base to apex, cell well thick, nodes hyaline and sometimes nodal portion swollen, apical cell pointed and slender.

..... *Colebrookia oppositifolia*

(7) Length 105-910 microns, max. width 42 microns, 1-5 celled, basal cell rounded, embeded in a crescent shaped epidermal cell, lumen very narrow, nodes swollen in older trichomes, cell wall hyaline and thick. apical cell broad and triangular.

..... *Leucas aspera*

(8) Length upto 200 microns max. width 21 microns generally six celled, sometimes 7-celled, stubby and blunt, smaller ones papillose.

..... *Emblica officinalis*

II - Trichomes Branched

IIA - *Two armed* :

(1) Unequal arms, thick walled, lumen present upto the tip, longer arms slender. Longer arm upto 630 microns in length and 35 microns in width, shorter arm upto 70 microns in length and 28 microns in width, tips acute, trichome attached to the epidermal cell on a ovoid disc.

..... *Diospyros melanoxylon*

IIB - *Trichomes stellate*

IIB1 - Trichomes constantly 4 armed :

(1) 4-arms almost equal or unequal in two pairs on a rounded basal cell, length of arms 315-740 microns, max. width 28 microns lumen narrow, discontinues near the tip, tip pointed and hyaline.

..... *Malvastrum tricuspidatum*

(2) 4-arms unequal, length of arms 70-450 microns, arms arranged in cruciform manner, rare in distribution.

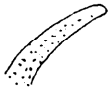
..... *Triumfetta neglecta*

IIB2 - Trichomes with variable number of arms :

(1) 3-7 armed, length of arms varies from 84-1820 microns, max. width 42 microns, arms seated on a common rounded basal

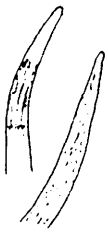
Trichomes of Different Plant Species

Shorea robusta



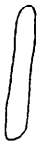
Aegle marmelos

Cassia tora *Limonea crenulata*



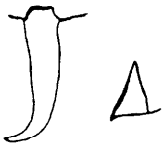
Murraya paniculata

Dalbergia sissoo



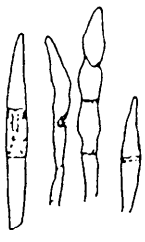
Bauhinia spp.

Terminalia chebula

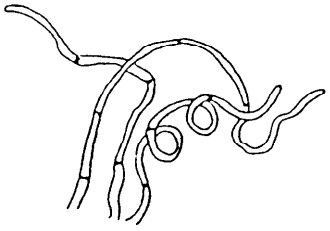


Grass

Woodfordia fruticosa



Albizia procera



Zizyphus mauritiana

cell. Sometimes longer arms are whipy, cell wall thin, lumen broad tip pointed, arms divergently oriented from the foot.

..... *Clerodendron infortunatum*

(2) 4-7 armed, unequal, sometimes almost equal arms arising from a bulbous foot. Length of arms varies from 70-980 microns, max. width 28 microns, lumen narrow, cell wall thick, tip pointed.

..... *Grewia elastica*

(3) 3-6 armed, of variable length from 105-1120 microns, max. width 56 microns seated on a rounded foot. Cell wall thick, lumen 1/3 of total width and triangular at the base, rare on leaves most abundant on fruit wall, tips blunt.

..... *Abutilon indicum*

(4) 2-3 armed, arms unequal, abundant on young fruits and flowers, rare on leaves, ephemeral, arms 140-350 microns, in length, width upto 35 microns arms, spinous with narrow lumen which ends 15-20 microns below the tip.

..... *Sida cordifolia*

(5) 6-8 armed, arms unequal, 50-500 microns, in length, max. width 28 microns, thick walls, narrow lumen tips acute.

..... *Helicteres isora*

(6) 5-11 armed, length of arms varies upto 400 microns, lumen narrow, tip acute.

..... *Pterospermum acerifolium*

IIC - *Dendritic Trichomes* :

(1) Dentritic with blunt, short conical branches with pitted inter-walls, thin walled, and lumen broad, length of branches 35-280 microns and width 28-30 microns.

..... *Tectona grandis*

2. Key based on Crystals

I - Monomorphic Crystals :

I A - *Crystals in the form of cystoliths* :

(1) Cystoliths uniformally distributed throughout the lamina, ovoid, length upto 175 microns and width upto 14 microns. Never associated with vascular tissues.

..... *Adhatoda vasica*

(2) Cystoliths sometimes at the base of trichomes, surrounded by smaller epidermal cells cystolith rounded, or almost rounded. Upto 94 microns in diameter. Never associated with vascular tissues.

..... *Diospyros montana*

(3) Cystolith club shaped, present in cortical region with narrow and near the epidermis. Never associated with vascular tissues.

..... *Rungia repens*

(4) Cystolith in lamina, very often at the base of the trichomes; epidermal cells walls thick at these places, round in shape, diameter upto 70 microns. No association with vascular tissues.

..... *Tectona grandis*

IB - *Crystal in idioblasts* :

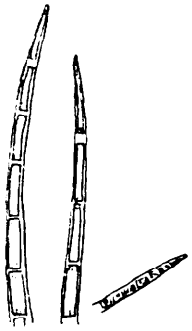
(1) Crystals in rosettes measuring upto 85 microns in diameter. Not associated with vascular tissues.

..... *Terminalias*

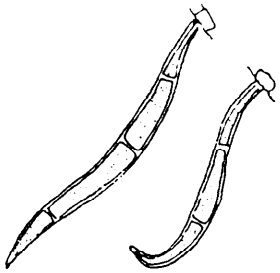
IC - *No cystoliths, crystals not in idioblasts* :

1 - Single prismatic crystals, abundant, positioned in parenchyma sheath surrounding vascular tissues and inside vascular fibres. Invariably associated with

Trichomes of Different Plant Species

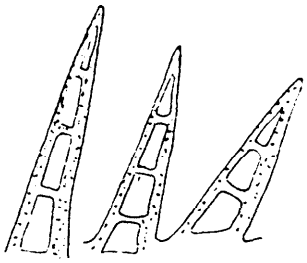


Zizyphus oenoplia

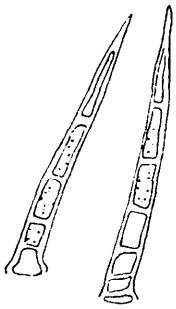


Ichnocarpus sp.

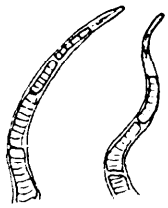
Hollarhena antidysenterica



Rungia repens

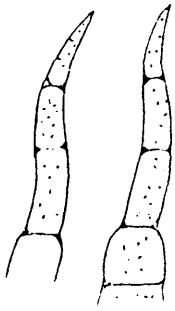


Ageratum conyzoides



Bridelia retusa

Putranjiva roxburghii



Adina cordifolia

vascular tissues.

..... *Acacias*

II - **Dimorphic Crystals** :

(a) Large prismatic crystals, occurs in mesophyll cells, cortical cells and pith cells i.e. in the soft-tissues. Distributed randomly. Not associated with vascular tissues.

(b) Crystals in rosettes, positioned and distributed as above.

.....*Emblica officinalis*

3. **Key based on Miscellaneous Structures**

I - *Epidermal features* :

(1) Cell walls of upper leaf epidermis very sinuous, stomata absent from upper epidermis.

.....*Diospyros melanoxylon*

(2) Stomata anomocytic.

.....*Rungia repens*

(3) Stomata diacytic, width of stomata including guard cells 28 microns.

.....*Cordia obliqua*

(4) Stomata sunken on amphistomatic leaves.

.....*Aerua tomentosa*

(5) Sinuous cells in leaf epidermis.

.....*Tectona grandis*

(6) Long and short epidermal cells arranged in parallel rows.

.....Any grass

II - *Sclereids in leaves*

(1) Sinuous sclereids on either side of veins in the ground parenchyma. They are rod shaped on the vascular tissue of veins.

.....*Desmodium pulchellum.*

(2) Sclereids interspersed with epidermal cells, rectangular, elongated sometimes oval in shape, frequently localised at certain places.

.....*Flemingia chappar*

(3) Sclereids found scattered in the mesophylle mostly oval in shape.

.....*Cassia tora*

(4) Sclereids concentrated in large clusters in the parenchyma cells, varied in shape.

.....*Cordia obliqua*

(5) Sclereids, rounded or oval in shape, in small to large clusters or solitary. Located in mesophyll

.....*Zizyphus mauritiana*

4. **Key based on Fruit and Seed tissues**

(1) Macrosclereids in the seed tissue and fruit epidermis, without crystals inside. Clusters of small rounded stone cells in the seed coat.

.....*Millotia auriculata*

(2) Macrosclereids in the fruit tissues, with prismatic crystals inside.

.....*Helicteres isora*

(3) Large clusters of angular stone cells in the fruit tissue.

.....*Terminalias*

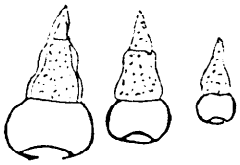
(4) Sinuons stone cells occurring in groups in fruit wall.

.....*Tectona grandis*

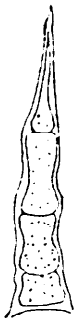
(5) Sligthtly thick walled stone cells with broad lumen and fine pits, length of cells

Trichomes of Different Plant Species

Vitex negundo



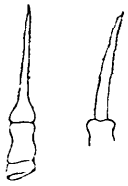
Xanthium strumanium



Tridax procumbens

Adhatoda vasica

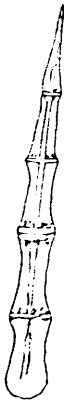
Euphorbia hurta



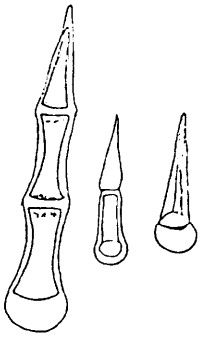
Achyranthus aspera

Emblica officinalis

Terminalia bellerica

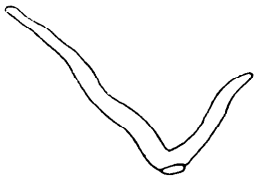


Colebrookia oppositifolia

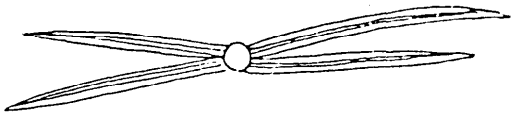


Leucas aspera

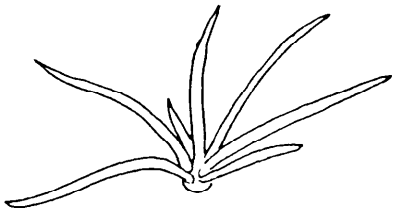
Trichomes of Different Plant Species



Diospyros melanoxylon

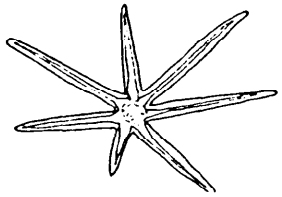


Malvastrum tricuspidatum

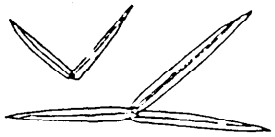


Clerodendron infortunatum

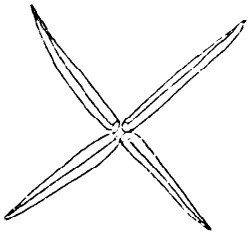
Grewia elastica



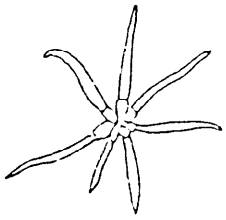
Abutilon indicum



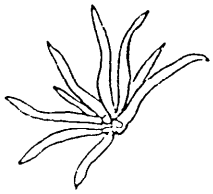
Sida cordifolia



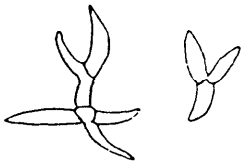
Triumfetta neglecta



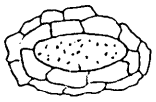
Helectres isora



Pterospermum acerifolium

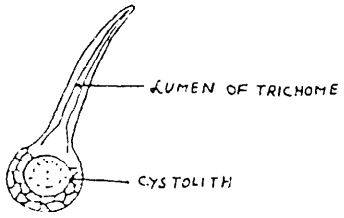


Tectona grandis

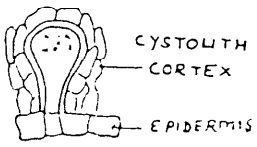


Cystolith of
Adhatoda vasica

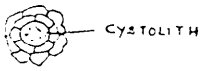
Resin cell of
Woodfordia fruticosa



Trichome with a basal cystolith
in *Diospyros melanoxylon*

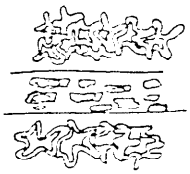


Rungia repens

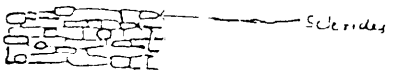


Tectona grandis

Sclereids in the leaf of
Zizyphus mauritiana

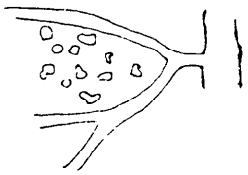


Schlereids in leaf
Desmodium pulchellum

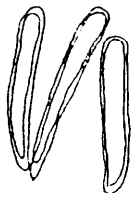


Sclereids in stem spidermis
Flemingia chappar

Sclereids in mesophyll tissue
of *Cassia tora*



Sclereids in leaf
Cordia obliqua

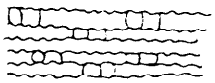


Macrosclereids in fruit epidermis of *Milletia auriculata*

Cluster of stone cells from fruit pulp and fruit skin of *Zizyphus* spp.

Cluster of stone cells in seed coat of *Milletia auriculata*

Filiform sclereids (clusters) in fruit wall of *Lagerstroemia parviflora*



Structure of epidermal piece of grass

always over 520 microns. Occur in fruit tussue.

.....*Emblica officinalis*

(6) Clusters of irregular, very thick walled and pitted stone cells, 105 microns in length and upto 90 microns in width. Lumen containing dark material. Occur in fruit pulp and fruit skin.

.....*Zizyphus* ssp.

(7) Filiform sclereids occurring in clusters in the fruit wall.

.....*Lagerstroemia parviflora*

Methodology of using the keys

A good research microscope with magnification from 100x to 200x is enough for the study. Use of stage micrometer and ocular micrometer is a must since almost all the characteristics used in the keys have been described by their dimension. Use of camera lucida for drawing and stereomicroscope for separating out dissimilar plant structures found in pellets, is desirable.

Thorough scanning of the slides, field by field, to cover the entire area of the slides under the cover slip covering the debris has to be done.

Supplementary keys have never to be used alone but always in association with main key based on trichomes.

Following precautions are to be taken while using the key.

(i) In their present form the keys should normally be used to identify plant material

in pellets collected in winter season since these have been based on the study of plant material and pellets collected during the winter season. Although, the keys can be used in other seasons also, but minor additions are required to be made, by the study of plant and plant parts and the pellets collected during those seasons, in order to identify whole range of plant remains the faecal pellets. For instances, no trichomes could be traced on the plant parts collected from *Carissa carandas, Bombax ceiba, Syzygium, cumini, Ficus* ssp. *Ougenia oojeinensis, Toona ciliata, Lannea grandis* and *Cassia fistula* during winter season. Because of this limitation, these species could not be included in keys. Other characters which could be solely assigned to these species were also not found. At this juncture, it is difficult to go to the extent of saying that trichomes are absent from these species because possibility of the ephemeral trichomes always exists. In still other but few cases, plants were in leafless condition; in such cases it was very difficult to correlate the leaves collected from forest floor to various plant species excepting a few cases where leaves were quite characteristic for the species and their assignment to the species were no problem. This is another limitation which prevented some species from their inclusion in the keys.

These limitations can be overcome by studying plants and plant parts of the species which have been left out from the keys and their subsequent inclusion in the keys. Once this is done the keys can be satisfactorily applied to all seasons.

(ii) Large number of pellet samples are required to be collected from the field for studying various aspects of food habits. Statistically designed sampling procedures must be followed to collect the representative samples for study.

(iii) Detached crystals are quite helpful in assigning them to plant species to which they belong especially when the morphology and dimensions are studied. But when crystals are found in association with other tissues, it has to be ascertained that they are found in the intact cell i.e. they are really associated with their parent cell and are not loosely associated with the tissues of the plants to which they do not belong. In the latter case erroneous conclusions may be drawn.

(iv) It has to be made very clear that the broken fibres of vascular systems are not confused with broken trichomes. Broken vascular fibres are characterised by the simultaneous presence of greater width, wide lumen irregular blunt tip and slit pits. Plant anatomy specialists are required to be consulted in case of confusion.

(v) A common phenomenon seen in the slides prepared from the pellets is the aggregation of various plant particles belonging to various plant species. In such cases various plant particles should be treated as a separate unit unless there is reason to believe that they belong to the same species, based on the actual tissue connection between the adjacent particles. Sometimes, one more prominent and casily identifiable particle may lie over less prominent ones making the identification of latter even more difficult rather impossible as they are not noticeable. In still other cases the arms of branched trichomes get broken and appear as broken unicellular trichome; although the detailed study of the structure and dimensions will solve the problem but such cases are no less puzzling especially for the beginers in the field.

(vi) The various keys have been based on the comparative studies of slides prepared from plant material with those prepared from faecal pellets. After having compared these the keys have been finally based on the characteristic as they are seen in slides prepared from plant material. While doing so, some of the plants which did not have their particles in the faecal pellets but which were intended to be included in the keys for future reference for studying other pellet samples, have been included in the keys only on the basis of the study of plant material.

Although the same procedure is followed in the preparation of slides from plant material and faecal matter but the same characteric appears to be slightly changed in the latter. In case of trichomes, for example, the cuticle of the trichome may get lost thereby causing a change in the morphorology of the walls. But this changed morphology is not constant, from species to species and from sample to sample. This is precisely the reason that the keys have been based on the basis of characteristics as they are seen in reference slides prepared from pure vegetative powders, and which may serve as standards. Whatever may be the degree of changes referred to above, the detailed study of the plant remains in the pellets including their study under high power of microscope will finally lead to their proper identification.

(vii) The key has been provided with most of the diagrams especially with regard to the main key. There should be no problem for using the key without studying the reference slides by making us of various morphological characters and dimensions described in the key.

(viii) In the field one of the important precaution to be taken in that the pellet samples collected must be relatively fresh i.e. they have to be collected before their disintegration starts.

Discussion

The study of food habits of various wild animals is of paramount importance in wild life management practices. Such studies are also helpful in law enforcement. There are three methods which are in use for studying food habits. First method consists in the direct observation of the animals while they are actually feeding on the plants in wild. This method requires that animals should be followed closely, if less conspicuous kinds of food are also required to be disclosed. Field observations often furnish considerable information concerning the kinds of food consumed but following animals closely over a large period of time is the main practical difficulty with this method. It is because of this difficulty that sometimes misleading results may be obtained with direct observation method. In the second method contents of digestive tract of killed or freshly dead animals are identified. This procedure has the advantage of showing more accurately what an animal has actually ingested; but has the disadvantage that the animal must usually be killed or a freshly dead animal has to be searched. The information obtained from this method is of one meal only or a portion of meal. It also gives no information on where the food was obtained. The third method consists in analysing animal faecal matter to identify indigestible or undigested parts which are present in practically all kinds of food, and eliminated out from the animal body along with the faecal matter.

The identification of indigestible or undigested food parts becomes easy if a key exists for identification of such parts as to their origin. With this idea in the present

work, keys for the identification of various plant parts in the faecal droppings of ungulate species feeding upon various plant parts having different origin, have been prepared, Such keys have to be different for different areas since the vegetational composition differs from area to area. The keys prepared for one area, if used for another area may lead to erroneous conclusions as this area will have different elements in the vegetational complex. In the present work the keys prepared for study area have been tested for their validity. The criteria used are the same as the ones used by Satakopan (1972). One wonderful criteria has been provided for the purpose by various characteristics of trichomes on which main key has been based. A closer appraisal of the key based on trichomes shows that there is sometimes considerable uniformity in trichomes within a plant group. On the other hand, the fact that trichomes may show variations within families and the smaller plant groups, and even in the same plant species is also indicated in the key. Plant hair types have been successfully used in the classification of genera and even of species in certain families and in recognition of inter specific hybrids (Cowan, 1950; Heintzelmann and Howard, 1948; Metcalfe and Chalk, 1950; Rollins, 1944). The present studies have also confirmed the constant and specific nature of the trichomes as the findings in the present work with regard to trichomes of *Acacia* ssp., *Anogeissus latifolia, Emblica officinalis, Terminalia bellerica, Diospyros melanoxylon, Helicteres isora* and *Zizyphus mauritiana* are similar to those in the work of Satakopan which also included these species. Almost similar conclusions can be drawn regarding the criteria used in preparing supplementary keys.

Key for the identification of grass species has not been attempted because identical characteristics of trichomes in all grass species do not permit their use for the preparation of such a key.

A key for the identification of grass spp. could have been prepared on the basis of epidermal cell characters as they are seen in pure grass material put such an attempt would have been futile as minute epidermal pieces that are seen in the pellets do not reveal cell characteristics. Satakopan (1972) has also found the same difficulties in the preparation of a workable key for identification of grasses upto the level of species. Probably sophisticated biochemical analysis will solve the problem which still remains.

Such keys as have been presented in this work will help in the study of various aspects of food habits including the establishment of palatability gradient of wild animals. For instance,if 100 pellet samples of a particular ungulate species have been collected following a statistically designed sampling procedure; and five slides have been prepared from each sample. Then if a plant species occurs in 490 slides out of 500, where as other plant species B occurs in 450 slides and still other species C occurs in 400 slides; than the species A will occupy the highest position in the palatability gradient. The species B and C will follow. thus the palatability gradient for that particular ungulate species can be written as A, B, C. In this method, the number of cases (slides) of the occurrences of a plant species have been correlated with the preference with which that plant species is eaten by the ungulate species. In the opinion of the author such a correlation should work.

But the palatability for a plant species will depend on the availability of various species as food in the area occupied by the

ungulate species, which goes on changing with season. Also, the availability of the annual plants entering into the composition of ground flora from year to year depends, amongst other factors, on the level of moisture in the soil which affects their emergence (Sharma, 1975). Therefore along with the studies on seasonal changes in the vegetation resulting from the various qualifiers in the area, the ecological studies of the ground flora, which will indicate the extent of availability of different species as food in the ground flora, should be made. Such studies should include the determination of relative frequency, relative density, relative cover for calculating importance value indices of various species. Determination of biomass should also be included in these ecological studies. Ecological monitoring can be done with the help of properly laid out samples based on conventional ecological methods. In the opinion of author such ecological monitoring should go hand in hand with the food habit study, if the latter is really intended to draw meaningful conclusions.

SUMMARY

This paper presents keys for identification of plant remains in faecal matter of ungulates. These Keys are useful in identification of indigestible or undigested food parts which are eliminated out from the animal body along with faecal matter. Main Key is based on trichomes and for cross checking the main key, supplementary keys have been based on features like crystals, epidermal cell characteristics, stomatal characteristics, sclerides, structural pecularities in fruit and seed tissues that are present in faecal matter of ungulates.

हिरणों के मेंगनी में पादप अवशेष पहचानने की कुंजियाँ

आर०डी० शर्मा

सारांश

इस अभिपत्र में हिरणों की मेंगनी में मिलने वाले पादप अवशेष पहचानने की कुंजी प्रस्तुत की गई है । यह कुँजी उन अपचनीय अथवा अनपचे भोजन अंशों को पहचानने में उपयोगी है जो पशुओं के शरीर से उनकी विष्ठा के साथ बाहर निकल आते हैं । प्रधान कुंजी ट्राइकोमों पर आधारित है तथा तिर्यक जाँच के लिए संपूरक कुंजियों स्फटिकों, उत्स्तर कोशा विशेषताओं, मुखीय विशेषताओं, स्कलेराइड, फल और बीज ऊतियों की संरचनात्मक विभिन्नताओं पर आधारित की गई है जो हिरणों की विष्ठा में पाई जाती है ।

References

Cowan, J.M. (1950). *The Rhododendron leaf: a study of the epidermal appendages.* Edinburgh, Oliver and Boyd.

Heintzelmann, C.E.Jr. and R.A. Howard (1948). The comparative morphology of Icacinaceae. V. The pubescence of the crystals, *Amer. Jour. Bot.* **35** : 42-52.

Metcalfe, C.R. and L. Chalk (1950). *Anatomy of Dicotyledons.* 2 Vols. Oxford, Clarendon Press.

Rollins, R.C. (1944). Evidence of natural hybridity between guayule (*Parthenium argentatum*) and mariola (*Parthemium inaanum*). *Amer. Courn. Bot.* **31**: 93-99.

Satakopan, Savitha, (1972). Keys to the identification of plant remains in animal droppings. *J. Bombay Nat. Hist. Soc.* **69** (1): 139-159.

Sharma, R.D. (1975). "Preliminary ecological and control studies of Kharif Weeds", *M.Sc. Thesis* submitted to Vikram University, Ujjain (Unpublished).