



PERSPECTIVE ON POLINIAL APPARATUS & CARRIERS OF ASCLEPIADACEAE *SENSU LATO*

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ABSTRACT

The agglutination pollen to form waxy pollinia is a rare event and is seen in the families, namely Asclepiadaceae and Orchidaceae. Terminology for the pollinia structures used has been analytically viewed. In Asclepiadaceae, the pollinial - apparatus are morphologically significant and varied. The characters of pollen - carriers and pollinial - apparatus are being used in classification of various taxa. Certain important characters of pollinial - apparatus and pollen - carriers are being considered in the text are very much valuable and they form key role in identifying species and genera. Additionally, the sites of germination of pollinia are important and distinct in different tribes of Asclepiadaceae and they are aptly placed on the stigmatic receptive surface by the highly evolved sophisticated method of insect pollination. Based on these, an evolutionary tree has been presented for the Asclepiadaceae *sensu lato*.

KEY WORDS: Pollen-carriers, pollinial-apparatus Asclepiadaceae, germination sites

INTRODUCTION

Among the Angiosperms, the two families namely the Asclepiadaceae and Orchidaceae, where pollen formed waxy pollen sacs. The formation of waxy pollen sacs in members of both the families is coincidentally associated with the evolution of sophisticated mechanism of insect pollination. Much work has been done on pollen grains of other families; this palynological data is of great value in solving the problems related to systematics and for pollen fossil records (Erdtman 1973, Franks and Watson 1963). However, there is a meager work, related to pollen morphology of the family Asclepiadaceae. Earlier to 1970 there was no much information was available about the pollen and waxy pollen sacs of the Asclepiadaceae. The pollen grains in Asclepiadaceae are all agglutinated, forming variously shaped waxy pollen sacs which are called pollinia, and in members of Periplocaceae pollen are in tetrads or pollen agglutinated to form pollen massulae. The Asclepiadaceae of *sensu lato* of Robert Brown has two sub families; Periplocoideae and *Cyananchoideae*. Bullock (1956), Santapau and Irani (1962), Hutchinson (1973) and Airy Shaw (1973) have preferred to treat the sub families as families, Periplocoideae as independent family, the Periplocaceae Schltr., mainly because, that this sub family has free stamens, spatulate pollen carriers and granular pollen and *Cyananchoideae* as Asclepiadaceae *sensu stricto* because of connate stamens, and a waxy pollinia. Subsequent approach has considered 2- sub families, namely *Secamonoideae* and *Asclepiadoideae*, on the basis of four anther locules in *Secamonoideae* and two in *Asclepiadoideae*, under Asclepiadaceae *sensu stricto* (Airy Shaw 1973).

Although, the early workers (Gager 1902, Richharia 1934 and Safwat 1962) have described the structure of pollinia in a few species of *Secamone*, but they have not visualized the importance of morphology of pollinia in taxonomy of

Asclepiadaceae. Gamble (1923) and Ronald Good (1956) have considered the orientation of pollinia in the flower and granular pollen and waxy pollinia for classification of different tribes of Asclepiadaceae *sensu lato*. An importance of morphology of pollinia in the taxonomy of Periplocaceae and Asclepiadaceae has been emphasized by El-Gazzar and Hamza (1973), El-Gazzar *et al* (1974), Rainer Schill and Ulrike Jakel (1978), Arekal and Ramakrishna (1978,1979,1980) and Ramakrishna *et al* (1995). The Asclepiadaceae is one of the interesting families, in having distinct floral morphology especially, the presence of gynostegium, pollen either in granular tetrads or waxy pollinia and highly evolved system of insect pollination. The paper is intended to through light on the morphology of granular pollen, waxy pollinia and other related aspects. In addition, the sites at which the pollinium germinates and its paramount importance in Taxonomy of Asclepiadaceae is also considered.

Terminology

There is no consistency in the use of terminology for the waxy pollen sacs since several decades. According to Lawrence (1951) in Periplocaceae, translator arms concavely spoon or cornucopia shaped ending below in an adhesive disc. In the Asclepiadaceae each pollinium bearing a translator, and translator arms of each pair of pollinia are joined by roughly saggitate body called 'gland'. Later, El-Gazzar and Hamza (1973) and Arekal and Ramakrishna (1978) used the term 'Twin Pollinia' for the entire structure. But, it is referred literally to mean two identical waxy pollen sacs only. Vijaraghavan and Shukla (1976) have described, the corpusculum and caudicle as translator apparatus while working with corpusculum and caudicle, the pollinia have not received importance in their work. In view of the above facts, there must be justification in the use of terminology. The present terminology used for granular pollen tetrad carrying structures in Periplocaceae as 'Pollen-carriers', whereas

the waxy pollen sacs along with caudicle and corpusculum of *Asclepiadaceae* as 'Pollinial-apparatus'.

The terms 'Pollen-carriers' and 'Pollinial-apparatus' used to distinguish the morphologically different entities. The circumscription of term pollen-carriers is characteristic of the family *Periplocaceae*, which consists of adhesive disc, stipe or stalk and spoon-shaped translator, which carries with it granular pollen or pollen massulae. Similarly, the Pollinial-apparatus of *Asclepiadaceae* consists of corpusculum; the caudicle is attached to corpusculum either at the bottom or top or in the middle. The caudicle and corpusculum, together is referred to as translator. The translator and a pair of pollinia together is termed as Pollinial-apparatus.

Pollen-carriers of Periplocaceae

There are five pollen-carriers in each flower. The pollen-carrier has an expanded distal erect translator, bent along with the stigma. Its proximal adhesive disc is directed towards the rim of the stigma. Both the translator and the adhesive disc are connected by the stipe. The translator, stipe and adhesive disc are non cellular and they are the products of secretion. The translators are boat-shaped in *Cryptolepis buchananii* (fig. 1), similarly, it is present in *Parquetina nigrescens*, and spoon-shaped in *Cryptostegia grandiflora* (fig.2) and in *Periploca nigrescens*. The shovel-shaped translator of both *Decalepis* and *Hemidesmus* (fig.3) has a median partition wall, dividing it into two parts, each of which receives pollen tetrads in massulae of the nearest anther lobe. The translator, stipe and the adhesive disc are distinct in *Hemidesmus* and *Decalepis* while the adhesive disc is not distinct and granular pollen in tetrads in *C. buchananii*. The pollen-carriers are erect in the *Periplocaceae*.

Pollinial - apparatus of Scamonoideae

The floral parts of the subfamily are very small. Each flower has five anthers with four sporangia in each forming a total of 20 pollinia. The pollinial pairs of the adjacent anther locules of the neighbouring anthers are connected together by a caudicle, which in turn is connected to the corpusculum. The pollinial-apparatus in all the species studied has a non cellular corpusculum and caudicle and cellular pollinia (figs. 4-5). The corpusculum is light brown in colour. The orientation of pollinia is erect, that is the vertical axes of the flower and pollinia are parallel and the free ends of the pollinia face upwards. The corpusculum and caudicle are membranous. The ventral surface of the corpusculum is in contact with stigmatic surface and the dorsal surface of the corpusculum has a median longitudinal suture. The suture is in alignment with a groove of the pentangular stigma.

Pollinial - apparatus of Asclepiadoideae

All the species examined under *Asclepiadoideae* possess multicellular pollinia, non cellular caudicles and corpuscles. The pollinial-apparatus are not morphologically identical. The characteristics of the pollinium such as orientation, length, shape, size and other aspects are presented in the Table -1.

Orientation of Pollinia

The pollinia in a flower are oriented in three different ways:

Erect: The vertical axes of the flower and pollinia are parallel and the free ends of the pollinia faces upwards. This is characteristic of the tribe *Ceropegieae*- *Caralluma indica*, *Ceropegia hirsuta* (figs. 6-7); *Huernia zebrina* (fig.12) and *Marsdenieae* - *Cosmostigma racemosum* (fig. 8), *Gymnema sylvestre*, *G. cuspidatum* (figs.9-10), *Hoya ovalifolia*, *H. wightii* (figs.11,13) *Leptadenia reticulata*, *Marsdenia raziana*, and *Wattakaka volubilis* (figs.14,15,16).

Horizontal: The vertical axes of the flower and pollinia are at right angles to each other and the free ends of the pollinia are disposed towards the exterior of the gynostegium as in some *Marsdenieae* such as *Tylophora capparioidifolia* and *T. indica* (fig.20)

Pendulous: The orientation of the pollinia is as in the erect type but the free ends of the pollinia faces downwards as in the tribe *Asclepiadeae*-*Calotropis gigantea* (fig. 19) *Holostemma ada-kodien* (fig. 21) *Pentatropis capensis* and *Oxystelma esculentum* (figs. 17,18)

Extrapollinial appendages: In some of the taxa a part of the pollinial body is thinner and it is sterile. This region may be either present on the lateral side or at the tip of the pollinium. In species of *Caralluma* and *Ceropegia* (figs.6, 7) and in species of *Brachystelma*, each pollinium has a tapering extended wing on the inner face of the pollinium. In *Hoya* (fig.13) on the other hand, the wing is located on the outer face of the pollinium. The free end of the pollinium is formed into a beak-like structure in *Leptadenia reticulata* (fig.15).

Corpuscles: The corpuscles are dark brown in colour and harder in consistency than that of the pollinia and caudicles. The corpusculum is a stunted unit of two halves, placed exactly at the angular region of the pentangular stigma. The surface which is adjacent to the stigma is the dorsal surface and the side opposite to it, is the ventral surface. The median longitudinal portion of corpusculum is sutured at various levels along both faces. The suture is open throughout on the ventral surface as in *Cosmostigma racemosum* (fig.8), *Gymnema sylvestre*, *G. cuspidatum* (figs.9,10) *Hoya wightii*, *H. ovalifolia* (figs.11,13) *Leptadenia reticulata*, *Marsdenia raziana*, *Wattakaka volubilis* (figs.14,15,16) and in all species of the tribe *Asclepiadeae* (figs. 17,18,19). The sutures in all the species of *Tylophora* are open along both the faces up to the head (fig.20).

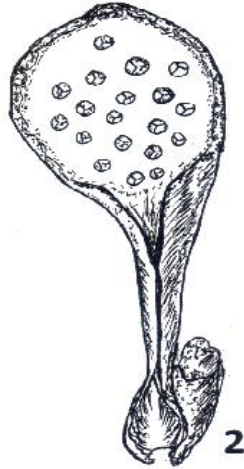
The corpuscles have a specific region to which the caudicle fits in. The split end of the corpusculum is usually associated with a membranous structure, except in *Caralluma adscendens*, *C. stalagmifera*, *Cosmostigma racemosum*, *Cynanchum alatum*, *C. callialata*, *C. tunicatum* and *Holostemma ada-kodien*.

Pollen carriers and Pollinial apparatus

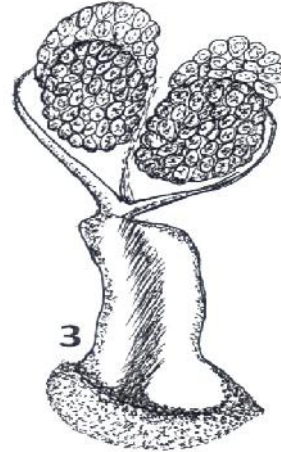
Cryptolepis buchananii (50.4 μm)



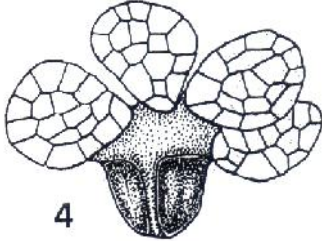
Cryptostegia grandiflora (5.2 μm)



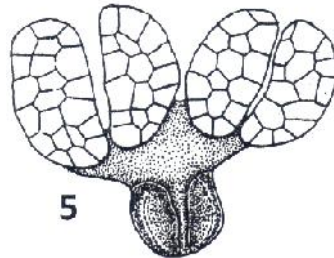
Hemidesmus indicus (109.2 μm)



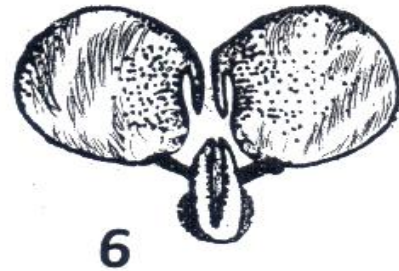
Genianthus laurifolius (12.0 μm)



Toxocarpus laurifolius (20.0 μm)



Caralluma indica (1.4 μm)



Ceropegia hirsuta (3.0 μm)



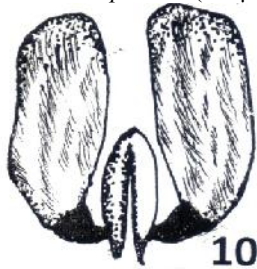
Cosmostigma racemosum (1.4 μm)



Gymnema sylvestre (4.6 μm)



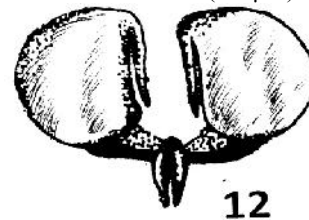
Gymnema cuspidatum (3.2 μm)



Hoya ovalifolia (1.25 μm)



Huernia zebrina (2.0 μm)



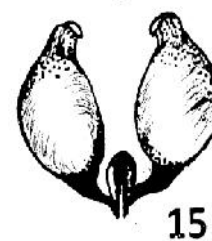
Hoya wightii (1.2 μm)



Marsdenia raziana (1.0 μm)



Leptadenia reticulata (2.0 μm)



Wattakaka volubilis (2.7 μm)

Pentatropis capensis (3.6 μm)

Oxystelma esculentum (0.8 μm)

Polinial apparatus & carriers of *Asclepiadaceae sensu lato*

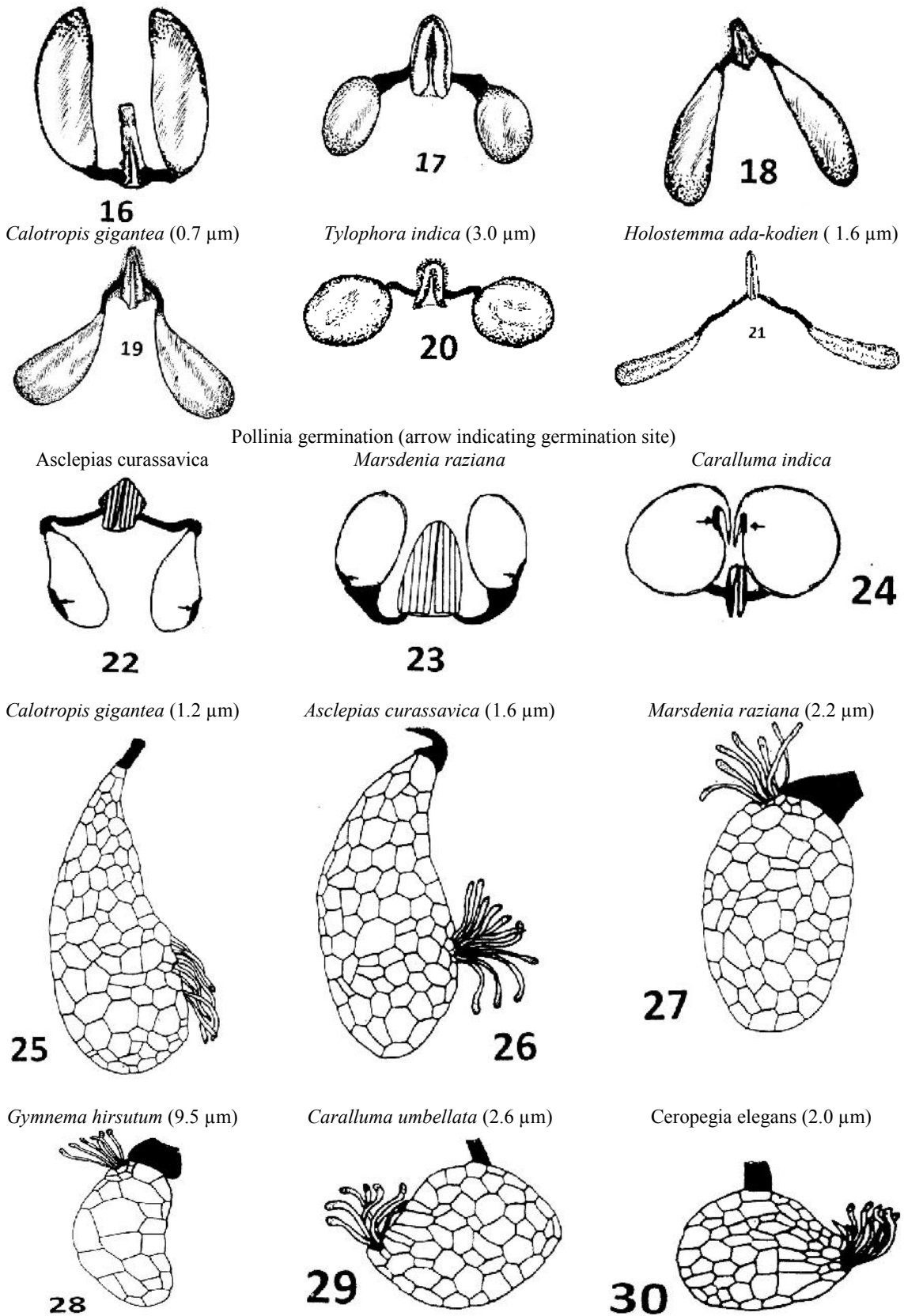


TABLE 1

Sl No	Name of the species	Pollinia			Corpusculum						Caudicle			
		1	2	3	4	5	6	7	8	9	10	11	12	13
1	<i>Asclepias curassavica</i> Linn.	1050	P	A	-	500	380	200	6	-	1	485	A	1
2	<i>Brachystelma ciliatum</i> Arek. et Ramakri.	205	E	D	1	150	75	60	4	-	2	45	C	2
3	<i>B. elenaduensis</i> (Char.) Ramakri.et Arek.	300	E	D	1	300	165	135	6	-	2	90	C	2
4	<i>B. kolarenses</i> Arek. et Ramak.	270	E	D	1	210	90	75	6	-	2	75	C	2
5	<i>B. laevigatam</i> Hk. f.	270	E	D	1	225	75	60	6	-	2	75	C	2
6	<i>Calotropis gigantea</i> , (L.) R. Br.	1850	P	A	-	850	375	150	1	+	1	420	A	1
7	<i>C. procera</i> (Ait.) R. Br.	875	P	A	-	450	240	50	1	+	1	360	A	1
8	<i>Caralluma adsendense</i> R. Br.	330	E	C	1	230	60	45	2	-	2	75	C	2
9	<i>C. indica</i> Wt. & Arn.	540	E	C	1	385	220	120	4	+	2	45	C	2
10	<i>C. stalagmifera</i> Fisch.	375	E	C	1	220	90	75	2	-	2	60	C	2
11	<i>C. procumbens</i> Grav. & Mayur	480	E	C	1	330	195	105	5	-	2	90	C	2
12	<i>C. umbellata</i> Haw.	400	E	C	1	240	120	60	4	+	2	90	C	2
13	<i>Ceropegia attenuata</i> Hook .	360	E	E	1	330	180	120	5	-	22	90	C	2
14	<i>C. bulbosa</i> Roxb.	270	E	E	1	105	45	45	2	-	2	30	C	2
15	<i>C. bulbosa</i> Roxb. var. <i>lushli</i> Hk. f.	285	E	E	1	90	37	45	6	-	2	30	C	2
16	<i>C.candelabrum</i> Linn.	260	E	E	1	135	90	60	5	-	2	45	C	2
17	<i>C.elcgans</i> Wall.	420	E	E	1	240	120	90	5	-	2	60	C	2
18	<i>C.hirsuta</i> Wt. & Arn.	450	E	E	1	375	200	60	5	+	2	105	C	2
19	<i>C. juncea</i> Roxb.	560	E	E	1	355	180	60	3	+	2	105	C	2
20	<i>C.spiralis</i> Wt.	345	D	E	1	300	165	105	5	-	2	60	C	2
21	<i>C. tuberosa</i> Roxb.	330	E	E	1	165	105	75	5	-	2	60	C	2
22	<i>Cosmostigma racemosum</i> (Roxb.) Wt.	600	E	G	-	345	120	90	1	-	2	500	A	1
23	<i>Cynanchum alatum</i> L.	240	P	H	-	320	150	90	4	-	1	75	B	1
24	<i>C. allialata</i> Ham.	420	P	H	-	450	300	120	4	-	1	150	B	1
25	<i>C. tunicatum</i> (Retz.) Alst.	375	P	H	-	350	210	90	4	-	1	135	B	1
26	<i>Gvmmema cuspidatum</i> (Thunb.) K. Schum	450	E	H	-	300	150	120	6	-	1	105	B	2
27	<i>G. hirsutum</i> Wt. & Arn.	210	E	H	-	120	60	60	1	-	1	45	B	1
28	<i>G.sylvestre</i> (Retz.) Alst.	160	E	H	-	120	60	60	1	-	1	50	B	1
29	<i>Heterostemma delzellii</i> Hook.f.	210	E	G	1	160	30	15	4	-	1	45	C	2
30	<i>Holostemma ada-kodien</i> Schults.	950	P	A	-	920	250	180	1	-	2	1140	A	1
31	<i>Hoya ovalifolia</i> Wt. & Arn.	560	E	G	2	210	150	110	1	-	2	105	C	1
32	<i>H. pauciflora</i> Wt.	560	E	G	2	375	260	150	1	-	2	105	C	1
33	<i>H. retusa</i> Dalz.	420	E	G	2	230	120	90	1	-	2	90	C	1
34	<i>H. wightii</i> Hook.f.	750	E	J	2	375	200	150	1	-	2	-	-	-
35	<i>Huernia macrocarpa</i> Schweinf.ex. K. Schm	480	E	F	1	200	150	90	1	-	1	90	B	1
36	<i>H. zebrina</i> N. E. Br.	670	E	F	1	400	180	135	1	-	1	105	B	1
37	<i>Leptadenia reticulata</i> (Retz.) Wt. & Arn.	480	E	J	3	150	105	60	4	-	2	240	B	1
38	<i>Marsdenia brunoniana</i> Wt. & Arn.	590	E	H	-	690	230	150	4	-	1	170	B	1
39	<i>M. raziana</i> Yog. & Subr.	720	E	H	-	700	390	290	4	-	1	500	B	1
40	<i>Oxystelma esculentum</i> (Linn.) Karst.	1190	P	A	-	405	290	150	1	+	1	120	A	1
41	<i>Pentatropis capensis</i> (Linn.f.) Bull.	270	P	D	-	290	160	90	4	-	1	120	B	1
42	<i>P. spiralis</i> (Forsk.) Decne.	240	P	D	-	350	230	200	4	-	1	135	B	1
43	<i>Pergularia daemia</i> (Forsk.)Chiov.	690	P	A	-	250	160	105	1	+	1	90	A	1
44	<i>Sarcostema aciduma</i> (Roxb.) Viogt.	345	P	A	-	245	110	70	6	-	2	190	A	1
45	<i>S. intermedium</i> Decne.	360	P	A	-	285	120	90	6	-	2	255	A	1
46	<i>Tylophora capparidifolia</i> Wt. & Arn	130	H	D	-	90	45	30	4	-	2	75	C	-
47	<i>T. dalzellii</i> Hk.f.	150	E	B	-	180	50	60	4	-	2	105	C	-
48	<i>T. fasciculata</i> Ham.	120	E	D	-	75	45	45	4	-	2	60	C	-
49	<i>T. indica</i> (Burm.f.) Merr.	210	H	D	-	135	105	75	4	-	2	90	C	-
50	<i>T. pauciflora</i> Wt. & Arn.	150	E	D	-	60	3	30	4	-	2	60	C	-
51	<i>T. rotundifolia</i> Ham.	180	E	B	-	120	45	45	4	-	2	75	C	-
52	<i>T. tenuis</i> Blum.	90	E	D	-	60	30	30	4	-	2	45	C	-
53	<i>Wattakaka volubilis</i> (Linn.f.) Stapf.	480	E	F	-	300	60	45	2	-	2	90	C	1

Explanation of the table (All measurements are in µm.)

Pollinia	
1.	Length
2.	Orientation E-erect P-pendulous H-Horizontal
3.	Shape: A- Club shaped B- globular with flat inner edge, D- globular oblong E-ovate or globular pyriform F-ovate elliptical G-ovate oblong H-oblong elliptical I-oblong linear J-oblong obovate
4.	Extrapollinial appendages: 1-wing inner 2-wing outer 3-beak
Corpusculum	
5.	Length
6.	Breadth at the broadest region
7.	Breadth at the caudical joining region
8.	Shape of head: 1-angular 2-flat 3-quadrangular 4- rounded 5- semi circular 6-tapered but rounded (middle broader)
9.	Lateral blades: +=present -= absent
10.	Sutured region: 1-open on the ventral face throughout 2-open on both faces but with intact head
Caudicles	
11.	Length
12.	Shape: A- club shaped B-triangular C- cylindrical
13.	Attachment with pollinia: 1-terminal 2-subterminal

Caudicles

The shape, size and orientation of caudicles are found to be significant in taxonomy. The caudicle in *Oxystelma esculentum* (fig.18) is very short, shoe- shaped and in *Cosmostigma racemosum* (fig. 8) it ends in a cup like- part to which the pollinium is glued. In *Hoya wightii* (fig. 13) the pollinium is directly attached to the corpusculum and there is no caudicle. The caudicle of *Tylophora indica* (fig.20) is cylindrical and ornamented on the surface.

The caudicle may be attached to the terminal or sub terminal region of the pollinium. Three types of caudicles are recognized; club-shaped, triangular and cylindrical. In *Asclepias*, the caudicle runs horizontally and then bends downwards at right angles and joins the pollinium. In *Holostemma ada-kodien* (fig.21), it is obliquely oriented downwards and attaches with the pollinium at the other end and in the middle, a horn-like structure faces upwards. The caudicle in the other taxa faces either obliquely upwards or downwards. The former type is found in species with erect pollinia, and the latter type in species with pendulous pollinia. In few others, the pollinia are horizontal and the caudicles run at a right angle to the long axis of the flower. In most of the taxa, the caudicle bears a membranous undulated structure.

Germination sites of Pollinia in Asclepiadaceae

The mode of pollinia germination has not received much attention till 1950s, it was Volk (1949) Galil and Zeroni (1969) have pointed out that in *Asclepias* the pollen tubes emerge at a defined site. Subsequently there was an attempt to make pollinial germination studies in different tribes by Ramakrishna and Arekal (1981-1982). The sites of germination in several genera such as *Asclepias* (figs.22,26), *Calotropis* (fig.25) and *Pergularia* the tribe Asclepiadeae lie near the point on the outer margin of the lower region. In *Marsdenia* (figs.23, 27), *Gymnema* (fig.28) and *Tylophora* of Marsdeniae the site of germination is near the caudicle attachment on outer margin at the upper region of the pollinia. In *Caralluma* (figs.24,29) and of *Ceropegia elegans* (fig.30), of the tribe Ceropegieae it is near the free point on the inner margin of the pollinia. A careful examination of pollinated flowers of the family has revealed that the location of site of germination of pollinia in every case remains the same as observed in, *in vitro*. Similar such observations have also

been made by Galil and Zeroni (1969) in the tribe Stapelieae (Ceropegieae *pro parte*)

DISCUSSION AND CONCLUSION

Evolutionary trends

The pollen-carriers of Periplocaceae are primitive in organization as compared to Asclepiadaceae pollinial-apparatus. Even among the genera of Periplocaceae such as *Cryptolepis* and *Cryptostegia* have less specialized pollen-carriers, while species of *Hemidesmus* and *Decalepis* have well organised pollen-carriers, nearly similar to that of pollinial-apparatus of Asclepiadaceae in having adhesive disc, stipe and a translator.

The pollen tetrads of *Cryptolepis* and *Cryptostegia* are free and scattered on the translator. An essentially similar condition has been recorded for *Apocynum* of Apocynaceae (Good 1955). This indicates that the genera of Periplocaceae and Apocynaceae are close to each other. The other genera of Periplocaceae such as *Hemidesmus* and *Decalepis* produce pollen massulae simulating the pollinia of Secamonoideae of Asclepiadaceae (Arekal *et* Ramakrishna 1980). In addition, the anthers of Periplocaceae are tetrasporangiate, like those of Secamonoideae. The erect orientation of pollen-carriers is similar to the type of orientation noted in the subfamily Secamonoideae and the tribes Marsdenieae and Ceropegieae of Asclepiadoideae. Apparently, the member genera of Periplocaceae strongly link to the genera of Apocynaceae to Asclepiadaceae.

Therefore, there appears to be a continuous specialization of pollen and pollen-carriers of Periplocaceae on the one hand, and the Asclepiadaceae on the other. However, Huber (1973), based on taxonomic studies of both the families Periplocaceae and Asclepiadaceae of Sri Lanka, concluded that “Both, Periplocaceae and Asclepiadaceae are derived from Apocynaceae. They are not closely related to each other than to Apocynaceae – Apocynoideae.” It is obvious to conclude that pollen-carriers of Periplocaceae is closely related to Apocynoideae of Apocynaceae, while the pollinial-apparatus of Asclepiadaceae has close relationship with the Periplocaceae and not with Apocynaceae. Therefore, there is an unmistakable evolutionary trend of pollen-carriers from *Apocynum* to Secamonoideae through the

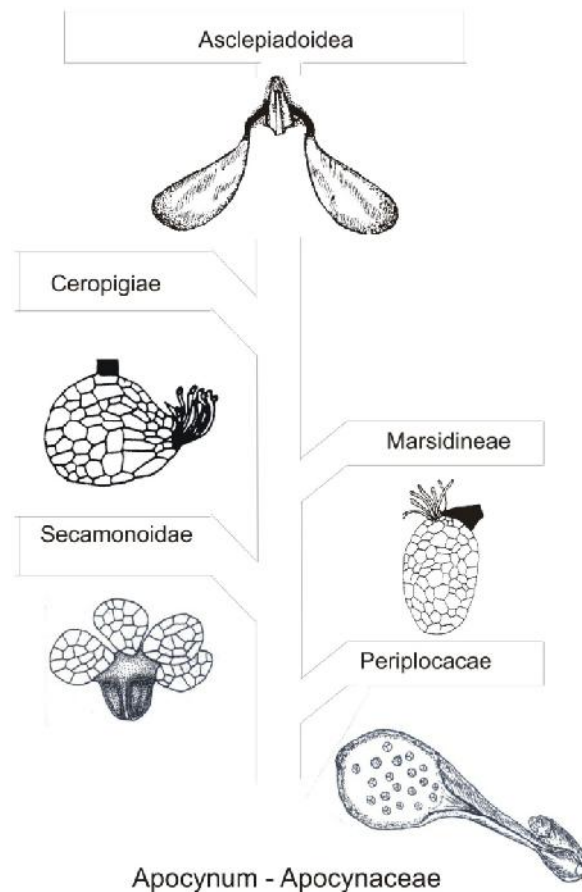
Periplocaceae. And there is no clue for the independent origin of Periplocaceae and Asclepiadaceae from Apocynaceae especially, morphology and evolutionary aspects of pollinial-apparatus are considered.

The pollinial-apparatus of Asclepiadoidea is more specialized than that of Secamonoidea. But Secamonoidea being closely related to Periplocaceae form a bridge between Periplocaceae and Asclepiadoidea. This is another evidence of specialization of the pollinial-apparatus from Apocynaceae to Asclepiadaceae. The lateral dehiscence of anthers associated with erect pollinia noted in the tribes Ceropegieae and Marsdeniae of Asclepiadoidea are features observed in the Secamonoidea of Asclepiadaceae and also in the members of Periplocaceae. But in the tribe Asclepiadeae of Asclepiadoidea, the anthers dehisce by apical pores and pollinia are pendulous. These features should be regarded as the most specialized. Consequently, the Asclepiadeae are the most specialized tribe in the entire Asclepiadaceae *sensu stricto*

The apical poricidal dehiscence is advanced over lateral longitudinal dehiscence of anthers, a character which is in support of the above facts that the Asclepiadeae is more evolved than the other tribes of Asclepiadoidea.

The studies so far demonstrated the existence of a continuity of evolution in the shape of pollinium. The pollinia of Ceropegieae are globular to globular-oblong and those of Marsdeniae globular-oblong to elliptic and club-shaped pollinia are consistently noted in members of Asclepiadeae.

The triangular caudicles in Marsdeniae of Asclepiadoidea bridge the Secamonoidea on the one hand and Asclepiadeae on the other. The single caudicle of Secamonoidea appears to have undergone a split vertically to give rise to two triangular caudicles such as noted in Marsdeniae. However, the cylindrical caudicles of Ceropegieae should be treated as a separate divergent line of evolution from Marsdeni



Systematic Significance

Despite the existence of continuity of evolution of the pollen-carriers from Apocynaceae to Asclepiadaceae, the Periplocaceae stands apart from Asclepiadaceae by the possession of free stamens, a distinct type of pollen-carrier, free pollen or with loose pollen massulae. The Asclepiadaceae is characterized by the presence of a staminal column, unique pollinial morphology. In addition the morphology of pollen-carriers of Periplocaceae and pollinial-apparatus of Asclepiadaceae is quite different.

Consequently, there is justification in creation of the family Periplocaceae (Hutchinson 1973).

The pollen-carriers of Periplocaceae are of significant systematic value not only in delimiting the genera and species. The pollen-carrier of *Cryptolepis* is boat-shaped, while it is spoon-shaped in *Cryptostegia*. There is no adhesive disc in both the genera. But in *Hemidesmus* and *Decalepis* there is an adhesive disc, stipe and translator for each of the pollen-carriers. Further, the pollen-carrier of *Decalepis* is larger than *Hemidesmus*. The stipe is short

and stouter in *H. indicus* var. *pubescens* than in *H. indicus* var. *indicus* (Arekal et Ramakrishna 1980).

The taxonomic significance of pollinial-apparatus in Asclepiadaceae is much more marked than that of Periplocaceae. As in the Periplocaceae, the genera, species and sometimes even varieties can be distinguished by the morphology of the pollinial-apparatus El-Gazzar and Hamza (1973), El-Gazar *et al* (1974) and Arekal and Ramakrishna (1978).

The pollinial - apparatus of the two subfamilies of Asclepiadaceae *sensu stricto* can be easily distinguished under the microscope. The corpusculum of secamonoideae is light brown and membranous against the dark brown and hard corpusculum Asclepiadoideae. Further, there is a single caudicle connecting all the four pollinia in Secamonoideae while there is a caudicle for each pollinium of Asclepiadoideae. The point of attachment of corpusculum to the caudicle is indistinct in Secamonoideae, while it is distinct in Asclepiadoideae. Therefore, it is logical to conclude that Secamonoideae and Asclepiadoideae are clearly defined within the Asclepiadaceae.

The size, shape and structure of pollinial - apparatus of Asclepiadoideae have been utilised for taxonomic delimitation. Further, the presence of membranous lateral blades and closed or open sutures on its ventral or dorsal sides of corpusculum are found to be taxonomic significance. The presence of different types of corpuscules and their winged nature in *Huernia macrocarpa* and *H.zebrina* are important distinguishing features.

The data presented in the table have revealed that the characters of Pollinial-apparatus of the sub-family of asclepiadoideae undoubtedly have diagnostic value. These characters are unique, for example in *Caralluma* the pollinia are globular with flat inner face and a characteristic wing. Likewise depending upon the shape of pollinium the genera like *Calotropis*, *Leptadenia*, *Pergularia* and *Sarcostemma* could be identified. Further, some of the pollinial characters are specific to particular species. The pollinia are ovate-oblong with a wing on the outer face in *Hoya ovalifolia*, *H. pauciflora* and *H. retusa*. In *Hoya wightii*, on the other hand, they are oblong-linear without the wing. The difference between the species of *Hoya* reveals that there is no similarity in any respect, except for the pollinial orientation.

Schumann (1895) recognized four tribes in Asclepiadaceae (Asclepiadeae, Secamoneae, Tylophorae and Gonolobeae). It is from our studies and from the earlier studies none of the members of Gonolobeae are available in India and hence the authors have considered only three tribes for classification, based on morphology of pollen-carriers and pollinial-apparatus.

The ultramicroscopic studies have revealed, the wall structure of the pollinia is predominantly tectate-imperforate, partly with extremely massive exine, partly with infratectal hollow spaces. Tectate-perforate, semitectate and intectate structures are restricted to the genera *Tylophora* and *Spaerocodon*. The exine is only formed by an ectexine; the intine often consists of two layers. The Cynanchoidae lack apertures. The tetrads of

the Periplocoideae are porate or semiaperturate-porate (Rainer Schill and Ulrike Jakel 1978).

Key to the family Asclepiadaceae *sensu lato*:

- I **Key to the family Perioplocaceae:** Pollen masses granular loosely contained in more or less spatulate structures.
- II **Key to the sub family Secamonoideae (Asclepiadaceae *sensu stricto*):** Pollen masses - 4, waxy
- III **Key to the sub family: Asclepiadoideae (Asclepiadaceae *sensu stricto*)** Pollen masses - 2, waxy
- IV **Key to the tribe Marsdenieae (Tylophorae *pro parte*)** Pollen waxy masses erect or horizontal, rarely pendulous
- V **Key to the tribe Ceropegieae (Tylophorae *pro parte*)** Pollen masses waxy, erect with a pellucid margin (wing)
- VI **Key to the tribe Asclepiadeae :** Pollen waxy masses pendulous

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