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Chromosome Base Numbers for *Tectaria* and Allied Genera in Peninsular Malaysia

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Abstract Cytological studies, especially with regard to the determination of chromosome base numbers for the genus *Tectaria* and allied genera have revealed the existence of a series of three base numbers, 39, 40 and 41, or strict multiple of these numbers. Four genera, *Ctenitis*, *Cyclopeltis*, *Pleocnemia*, and *Pteridrys* have been determined to have a base number of 41. *Heterogonium* has $n=40$, while *Tectaria* has been confirmed in the present study to harbour two chromosome base numbers i.e. 39 and 40.

Key words: Chromosome base number, *Ctenitis*, *Cyclopeltis*, *Heterogonium*, *Pleocnemia*, *Pteridrys*, *Tectaria*, Peninsular Malaysia.

The development of fern cytology is more recent than that of flowering plant cytology, which extends back to the last century. The reason is mainly because accurate techniques were not available to counter the problems of high chromosome numbers and material that was extremely difficult to handle, such as root tips.

Before the application of Mantons technique (Manton, 1950) most of the thousands of publications on the pteridophytes were based on morphological and anatomical studies. Only very few reliable chromosome counts were made before that time. The high success rates of Manton's squash techniques has enabled researches to explore the evolutionary studies of many fern floras from geographical areas such as the Americas, Britain, West Africa, India, Japan, Malaysia and Australia.

Cytological work on Malaysian pteridophytes was initiated by Manton, with a total of 101 species distributed among 43 genera analyzed for their chromosome numbers (Manton, 1954). This was a major initial study but unfortunately it was not followed by other workers, apart from a few sporadic counts made by Jermy on the allied fern genus *Selaginella* (Jermy *et al.*, 1967), Bidin on a number of Malaysian *Adiantum*, *Psilotum* and *Osmunda* (Bidin, 1983, 1984, 1988) and Walker (1979) on *Christensenia*.

Bearing this in mind, an initiative was undertaken to carry out an investigation based on *Tectaria* and allied genera found in Peninsular Malaysia involving the determination of chromosome numbers in order to establish the exact chromosome base numbers for the group.

Live specimens were collected from various localities (mainly limestone) in Peninsular Malaysia and planted at the University Fern Gardens (Universiti Kebangsaan Malaysia Fern Gardens). During the course of the work, it was found that the genus is fairly variable in its behavior in cultivation, some taxa reaching maturity very rapidly whilst others take years to do so. They are also particularly susceptible to damage from snails, slugs and insects.

Materials and Methods

Source of materials

The materials used for cytological studies were derived from two sources:

i. Fixed sporangial materials from plants grown in cultivation at Universiti Kebangsaan Malaysia Fern Gardens.

ii. Material fixed in situ at various localities in Peninsular Malaysia.

Methods

In all cases the sporangial materials were fixed in one part glacial acetic acid to three parts of absolute alcohol stored in the freezer at $-25°C$.

The squashing, staining in aceto-carmine and recording techniques are standard (Manton, 1950).

Results and Discussion

The taxonomic position of the fern genus Tectaria and allied genera in Malaysia had been investigated by Holttum and published in numerous publications (Holttum, 1950, 1954, 1968, 1974, 1984, 1991). Holttum, in his book of 1966, subdivided the subfamily Tectarioidea of the family Dennstaedtiaceae into two major groups centred on *Tectaria* and *Pleocnemia*. However, Holttum (1991), based on various aspects of morphology, anatomy and some cytology and cell ultrastructure, dissolved the *Pleocnemia* group and incorporated it into the single, enlarged *Tectaria* group. Thus *Tectaria* sensu Holttum (1991) comprises 11 genera of which six are recorded for Peninsular Malaysia: *Ctenitis*, *Cyclopeltis*, *Heterogonium*, *Pleocnemia*, *Pteridrys*, and *Tectaria* (Table 1).

In terms of the number of species as well as the number of individual plants for each species, the *Tectaria* group forms a conspicuous part of the fern flora of Peninsular Malaysia. The majority of the species are found in undisturbed habitats of the lowlands forests on granite as well as limestone.

The two most distinctive and widely distributed species are the simple-fronded *Tectaria singaporeana* and the pinnately-divided *Pleocnemia irregularis*. *Tectaria singaporeana* is a diploid species commonly inhabiting humid undisturbed forest, especially in shaded alluvial places near rivers or streams. *Pleocnemia irregularis* is larger and dimorphous, and commonly found on the limestones of the west coast of Peninsular Malaysia. It is also diploid.

Table 1. List of genera and species numbers in the Tectarioid ferns for the Malesian region and in Peninsular Malaysia (After Holttum, 1991).

Genus	Number of Species	
	Malesia	Peninsular Malaysia
Pteridrys	6	3
Pleocnemia	20	4
Ctenitis	28	2
Tectaria	105	28
Heterogonium	22	4
Cyclopeltis	5	1
Lastreopsis	4	0
Psomiocarpa	1	0
Aenigmopteris	5	0
Chlamydogramme	2	0
Tectaridium	1	0

The emphasis of the present study has been almost exclusively upon the determination of chromosome numbers (particularly on level of ploidy) in order to establish the chromosome base numbers for the *Tectaria* group. The specimens examined for this purpose are listed in Table 2.

If the results (gametic chromosome numbers) of all individuals examined are added to the records already available in the literature (Manton 1954), the chromosome numbers of some 34 taxa are now known (Table 3). This is distributed among the different ploidy levels as follows:

	2*x*	4*x*	Total
Number of taxa:	24	10	34
% of each class:	70.6	29.4	100

The diploids comprise 70.6 of the total with the polyploids being at the tetraploid level only i.e. polyploidy is at a generally low level with none of the taxa investigated above that level. These findings agree with the chromosome numbers for the *Tectaria* group reported from other geographical areas (Lovis, 1977). These figures favour the hypothesis that *Tectaria* and allied genera had their origin in the Malesian region.

The present study has also revealed the existence of two base numbers for the genus *Tectaria*, i.e. 39 and 40 and verifies the formerly reported basic chromosome numbers in other genera allied to *Tectaria* (40, 41: Table 4). Representatives of these species are shown in Figures 1 and 2. It is suggested that the number 40 is the more primitive one from which the base numbers 39 and 41 may have been derived as a result of aneuploidy, i.e. ± 1.

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Table 2. List of specimens examined. (Notes: K=The Herbarium, Kew, England; UKMB=The Herbarium, Universiti Kebangsaan Malaysia, Bangi; SING=The Herbarium, Singapore).

Species	Locality	Collector	Colletion Number	Dated	Herbarium
1. *Ctenitis subobscura*	Assam, Dighoi			Jan 1891	K
2. *C. vilis*	Malaysia, Pahang, Taman Negara	Rusea Go	RA593, RA599	25/5/91	UKMB
3. *Cyclopeltis crenata*	Malaysia, Perak, Felda Lasah	Rusea Go	RA276, RA278	28/10/90	UKMB
	Malaysia, Pahang, Taman Negara	B. S. Parris & P. J. Edwards	10362	28/2/85	UKMB
4. *Heterogonium alderwereltii*	Malaysia, Selangor, Bkt. Takun	Rusea Go	RA700, RA701,	16/3/92	UKMB
	Malaysia, Selangor, Batu Caves	C. G. Mathew R.N.	RA707	4/1/07	K
5. *H. pinnatum*	Malaysia, Perak, Larut	Dr. King	2236	8/18/81	K
6. *H. pinnatum*	Malaysia, Selangor, Bkt. Takun	Rusea Go	RA162, RA165	26/9/90	UKMB
	Kelantan, Gua Cha	Rusea Go	RA540	5/1/91	UKMB
	Perak, Sg. Siput	Rusea Go	RA250	24/10/90	UKMB
7. *H. sagaenoides*	Malaysia, Pahang, Taman Negara	Rusea Go	RA598, RA628	18/5/91	UKMB
8. *Pleocnemia conjugata*	Malaysia, Pahang, Pulau Pulau Tioman, G. Kajang	Razali Jaman Zulkifli Mohamad	RJ2827	3/8/90	UKMB
9. *P. irregularis*	Malaysia, Perak, Lata Kekabu	Rusea Go	RA267	27/10/90	UKMB
10. *P. olivacea*	Malaysia, Pahang, Taman Negara; Kuala Kenyam	B. S. Parris & P. J. Edwards	10458	7/3/85	UKMB
11. *Pteridrys australis*	Malaysia, Pahang, Taman Negara, Sg. Renuis	B. S. Parris & Croxall	10419	4/3/85	UKMB
12. *P. syrmatica*	Malaysia, Pahang, Pulau Tioman, G. Kajang	Razali Jaman & Zulkifli Mohamad	RJ2826	3/8/90	UKMB
13. *Tectaria angulata*	Malaysia, Selangor, Bukit Takun	Ismail Sahid	231	17/8/74	UKMB
14. *T. barberi*	Malaysia, Perak, KM 18, Jln. Tapah-Cameron Highlands	Razali Jaman & M. Dinear	RJ3185	15/7/91	UKMB
15. *T. brachiata*	Nalaysia, Kedah, Pulau Langkawi, Perak, Pulau	Razali Jaman & A. Zainuddin	PL34	16/1/86	UKMB
	Pangkor, Telok Nipah	Razali Jaman, Lagani Sahid & Sani Miran	RJ3078	30/12/89	UKMB
16. *T. cherasica*	Malaysia, Pahang, Gua Charas	Rusea Go	RA585, RA588 RA596	26/7/91	UKMB
17. *T. crenata*	Malaysia, Pahang, Batu 23 Jln. Tapah-Cameron Highlands	Rusea Go	RA517, RA518	15/3/91	UKMB
18. *T. coadunata*	Malaysia, Pahang, Gua Charas	Rusea Go	RA583, RA586	26/7/91	UKMB
19. *T. curtisii*	Malaysia, Kelantan, Jeli, G. Reng	Rusea Go	RA634, RA637	3/9/91	UKMB
20. *T. decurrens*	Malaysia, Perak, Gopeng	L. B. M. Allen	4486	13/2/60	K
21. *T. decurrens*	Malaysia, Selangor, Bkt. Takun	Rusea Go	RA202, RA207, RA212	4/10/90	UKMB
	Batu Caves	Rusea Go	RA180, RA183	27/9/90	UKMB
	Kelantan, Gua Cha	Rusea Go	RA541	1/5/91	UKMB
22. *T. fauriei*	Thailand, Ching Rai, Nam Mae Kok	K. Iwatsuki, N. Fukuoka, M. Hutoh & D. Chaiglom	T10888	23/9/67	K
23. *T. fissa*	Malaysia, Selangor, Klang Gates	Rusea Go	RA391, RA397, RA400	12/2/91	UKMB
24. *T. grandidentata*	Malaysia, Selangor, Kerling, Bkt. Tarek	Rusea Go	RA533, RA536	17/10/91	UKMB
25. *T. griffithii*	Malaysia, Selangor, Bkt. Takun	Rusea Go	RA151, RA152,	26/9/90	UKMB
	Pahang, Cameron Highlands, Kuala Boh	Rusea Go	RA526	16/3/91	UKMB

Table 2. (continued)

Species	Locality	Collector	Collection Number	Dated	Herbarium
26. *T. herpetocaulos*	Thailands, Koa Kanching	Dr. Eryl Smith	8647	11/3/24	K
27. *T. impressa*	Malaysia, Perlis, Wang Klian	Rusea Go	RA506, RA510	28/2/91	UKMB
	Kedah, Pulau Langkawi	A. A. Bidin	PL222	18/1/86	UKMB
28. *T. keckii*	Malaysia, Selangor, Bkt. Takun	Rusea Go	RA142, RA153	26/9/90	UKMB
	Templer Park	Rusea Go	RA338		UKMB
29. *T. manilensis* var. *chupengensis*	Malaysia, Perlis, Bkt. Chupeng	C. G. Mathew R.N.	703	3/2/14	K
30. *T. melanocaula*	Sulawesi, Mt. Wawonseru	E. Hennipman	6088	1/7/79	K
	Malaysia, Cameron Highlands	L. B. M. Allen	3958		K
31. *T. semibipinnata*	Malaysia, Johor, Kota Tinggi, Sg. Lalang	Rusea Go	RA650, RA653	8/9/91	UKMB
	Johor, Sg. Tersap	R. E. Holttum	24910	6/7/31	SING
	Johor, Kota Tinggi, Kpg. Sg. Lalang	L. B. M. Allen		29/6/59	SING
32. *T. semipinnata*	Malaysia, Kedah, Pulau Singa,	Rusea Go	RA474	25/2/91	UKMB
	Pulau Langkawi, Lubuk Sembilang	Rusea Go	RA485	28/2/91	UKMB
	Pulau Langkawi, Hutan Simpan Machinchang	Rusea Go	RA481	26/2/91	UKMB
33. *T. siifolia*	Malaysia, Selangor, Bkt. Anak Takun	Rusea Go	RA349	22/11/90	UKMB
	Perak, Sg. Siput	Rusea Go	RA263	26/10/90	UKMB
34. *T. simonsii*	Malaysia, Pahang, Batu 23, Jalan Tapah-Cameron Highlands	Rusea Go	RA515, RA520, RA521, RA525	15/3/91	UKMB
35. *T. singaporeana*	Malaysia, Pahang, Taman Negara	B. S. Parris & P. J. Edwards	10400	6/3/85	UKMB
36. *T. translucens*	Malaysia, Selangor, Bkt. Takun	Rusea Go	RA155, RA156	26/9/90	UKMB
	Bkt. Takun	Rusea Go	RA704, RA706	16/3/92	UKMB
	Pahang, Taman Negara, Bkt. Batu Luas	B. S. Parris & P. J. Edwards	10450	7/3/85	UKMB
37. *T. tricuspis*	Malaysia, Pahang	Dr. king	1975	1/18/80	K
38. *T. vasta*	Malaysia, Pahang, Batu 23, Jalan Tapah-Cameron Highlands	Rusea Go	RA515, RA516 RA519	15/3/91	UKMB
39. *T. zeilanica*	Malaysia, Pulau Tioman, Tekek, Tanjung Pak Seman	Rusea Go	RA110, RA115	26/8/90	UKMB
40. *Tectaria* sp. I	Malaysia, Perlis, Wang Klian	Rusea Go	RA506, RA507, RA509, RA512	28/2/91	UKMB
41. *Tectaria* sp. II	Malaysia, Kelantan, Gua Cha	Rusea Go	RA540, RA543, RA546	1/5/91	UKMB

Table 3. List of species studied and chromosome numbers determined. The list includes chromosome numbers determined by Manton (1954) and Manton & sledge (1954).

Genus/Species	Chromosome Numbers		
	n	Ploidy	References
Ctenitis vilis	41	2*x*	Present Investigation
C. subobscura	—	—	Fresh specimen not available
Cyclopeltis crenata	41	2*x*	Present investigation
Heterogonium alderwereltii	40	2*x*	Present Investigation
H. giganteum	—	—	Fresh specimen not available
H. pinnatum	80–2	4*x*	Manton (1954)
H. sagaenoides	40	2*x*	Manton (1954)
Pleocnemia conjugata	41	2*x*	Manton (1954)
P. hemiteliiformis	41	2*x*	Manton (1954)
P. irregularis	41	2*x*	Present investigation
P. olivacea	41	2*x*	Present investigation
Pteridrys australis	41	2*x*	Manton (1954)
P. syrmatica	41	2*x*	Present Investigation
Tectaria angulata	40	2*x*	Present Investigation
T. barberi	78–80	4*x*	Manton (1954)
T. barberi	40	2*x*	Present investigation
T. brachiata	78	4*x*	Present investigation
T. cherasica	40	2*x*	Present investigation
T. coadunata	40	2*x*	Present investigation
T. curtisii	40	2*x*	Present investigation
T. decurrens	—	—	Fresh specimen not available
T. devexa	40	2*x*	Monton (1954)
T. fauriei	—	—	Fresh specimen not available
T. fissa	40	2*x*	Present investigation
T. grandidentata	78	4*x*	Present investigation
T. griffithii	40	2*x*	Present investigation
T. herpatocaulos	—	—	Fresh specimen not available
T. impressa	78	4*x*	Present investigation
T. keckii	40	2*x*	Manton (1954, as T. amplifolia)
T. manilensis var. *chupengensis*	—	—	Fresh specimen not available
T. melanocaula	—	—	Fresh specimen not available
T. semibipinnata	39	2*x*	Present investigation
T. semipinnata	40–1	2*x*	Manton (1954, as T. maingayi)
T. siifolia	78	4*x*	Present Investigation
T. simonsii	78	4*x*	Present Investigation
T. singaporeana	39	2*x*	Manton (1954)
T. translucens	78	4*x*	Present Investigation
T. tricuspis	—	—	Fresh specimen not available
T. vasta	78	4*x*	Present Investigation
T. zeilanica	40	2*x*	Manton and Sledge (1954)
Tectaria sp. I	40	2*x*	Present Investigation
Tectaria sp. II	78	4*x*	Present Investigation

Table 4. Comparison of chromosome base numbers in *Tectaria* and its allied genera under investigation.

Genus	Manton 1955 in Holttum, 1966	Walker 1966–73	Lovis 1977	Present Investigation
Ctenitis	41	41	41	41
Cyclopeltis	—	41	41	41
Heterogonium	40	—	40	40
Pleocnemia	41	—	—	41
Pteridrys	41	—	—	41
Tectaria	40	40	40	39 & 40

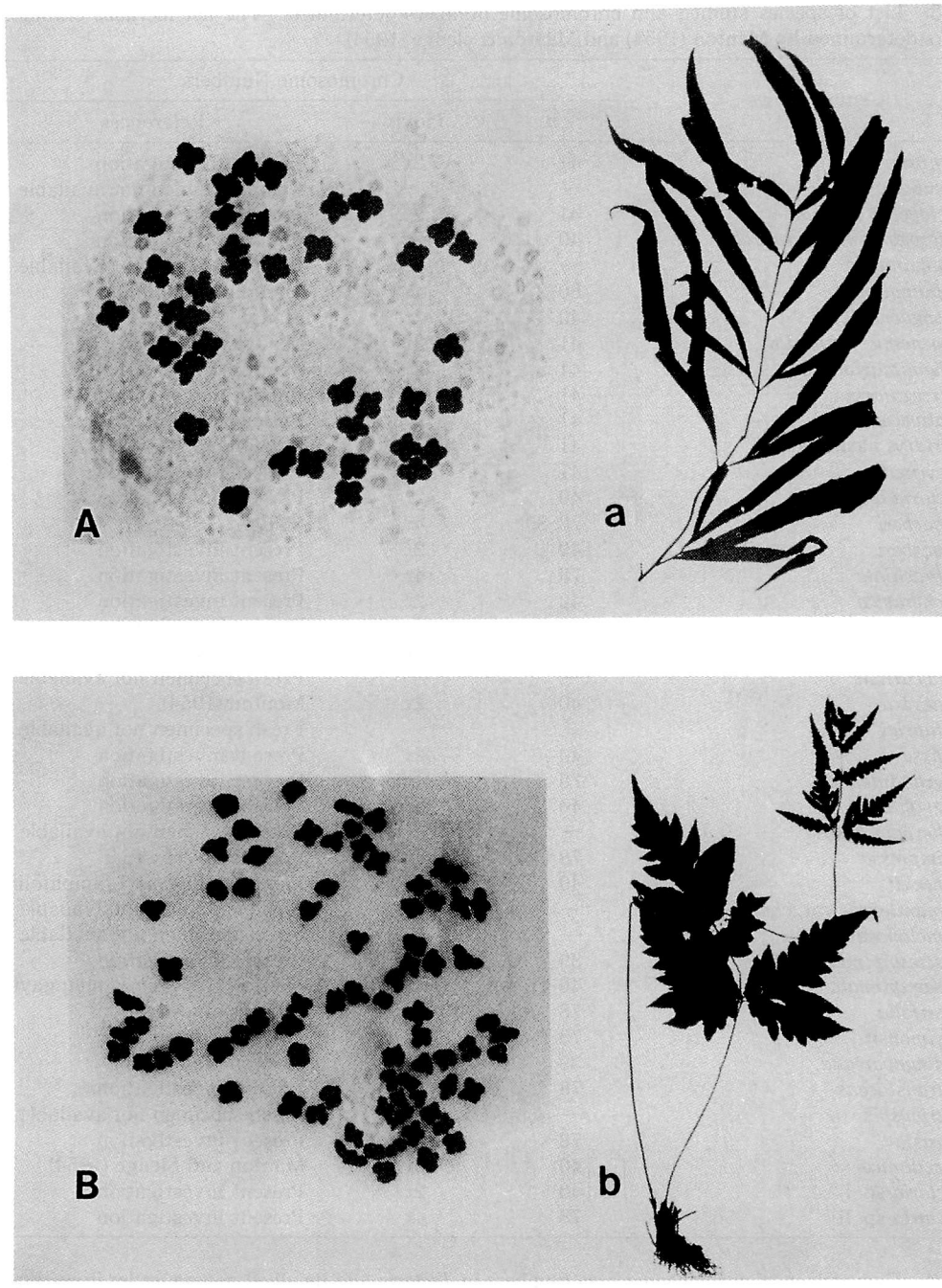

Fig. 1. Meiotic plates and silhouettes of representative species with base numbers $n=39$ and $n=78$. A, a: *Tectaria semibipinnata* (Wall. *ex* Hook.) Copel.: A, meiotic plate (base number $n=39$); a, silhouette (RA650). B, b: *Tectaria impressa* (Fée) Holtt.; B, moiotic plate (base number $n=78$); b, silhouette (RA506).

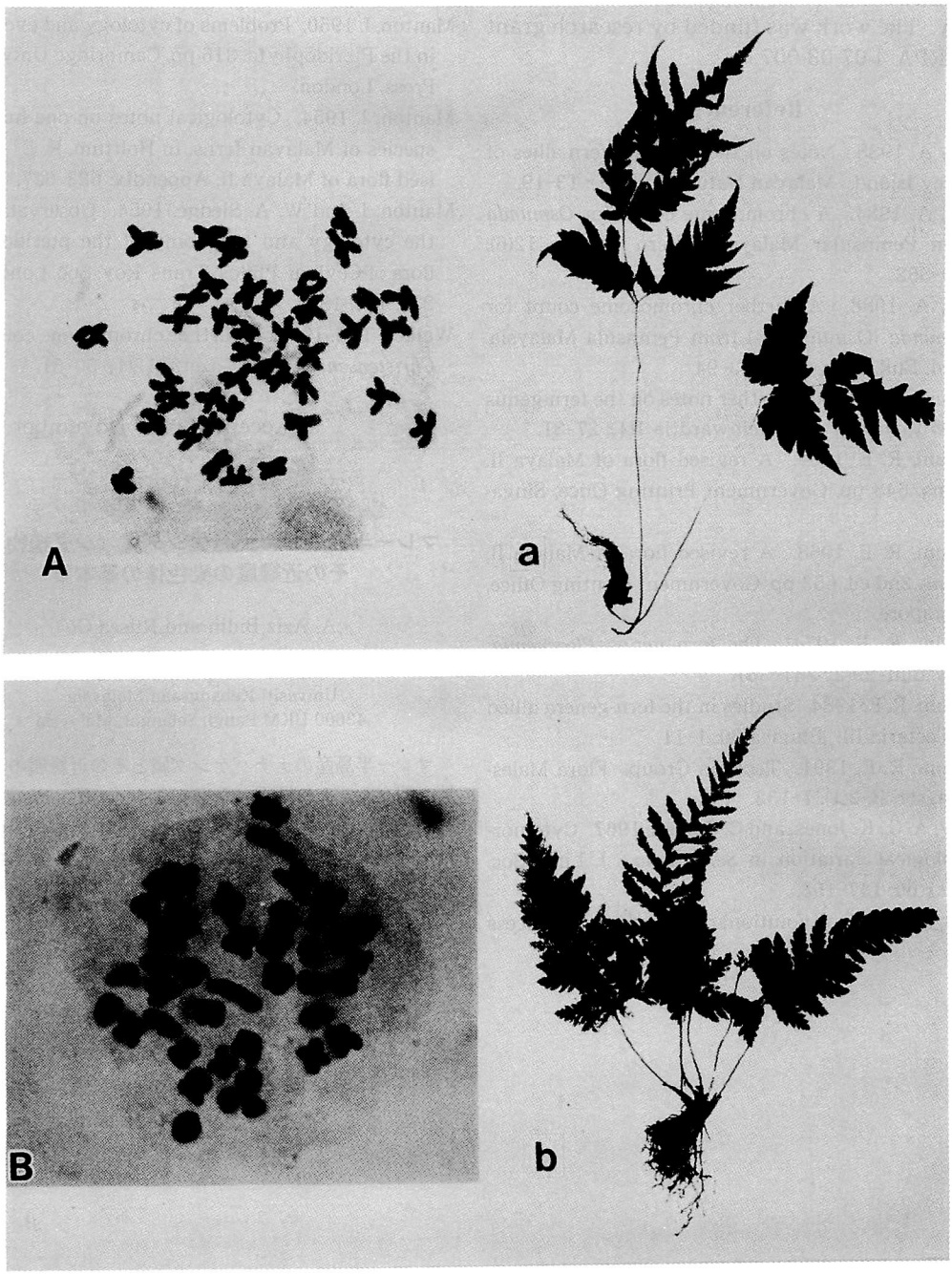

Fig. 2. Meiotic plates and silhouettes of representative species with base numbers $n=40$ and $n=41$. A, a: *Tectaria cherasica* Holtt.; A, meiotic plate (base number $n=40$); a, silhouette (RA585). B, b: *Ctenitis vilis* (Kunze) Ching.; B., meiotic plate (base number $n=41$); b, silhouette (RA593).

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マレー半島産のナナバケシダ属（シダ植物）とその近縁属の染色体の基本数

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マレー半島産のナナバケシダ属とその近縁属の染色体数を調べた．その結果，カツモウイノデ属，*Pleocnemia* 属，*Pteridrys* 属，*Cyclopeltis* 属のそれぞれの染色体の基本数が $x=41$, *Heterogonium* 属の基本数が $x=40$，ナナバケシダ属の基本数が $x=39, 40$ であることが明らかになった．