

MORPHOLOGY AND VARIATION OF JUVENILE LEAVES IN *ACACIA CONFUSA* MERR.⁽¹⁾

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Abstract: The juvenile leaves of *Acacia confusa* Merr. were investigated with regard to their structure, number, and developmental pattern. The morphology of the seedlings was redescribed and the evolutionary relationship of this species with other *Acacias* and the adaptability of *A. confusa* were discussed.

INTRODUCTION

It has been accepted that in the genus *Acacia* the phyllodinous types have been derived from their bipinnate ancestors (Stebbins 1967). This assumption is strongly supported by the presence of bipinnate juvenile leaves in many species (Athchison 1948). However juvenile foliage of phyllodinous acacias are not as simple as reported. Many authors have reported on various species of juvenile leaves but very few of them have studied the seedlings of *Acacia confusa* Merr., which is an endemic species in Taiwan.

The purpose of this investigation is to examine the juvenile leaves of *Acacia confusa* including their structure, number, and the developmental pattern of their cophylls (those first few leaves succeeding the cotyledons). The number and structure of the transitional bipinnate leaves (if present) were also studied. The evolutionary relationship of this species with other *Acacia* and the adaptability of this species is discussed.

LITERATURE REVIEWED

For years the evolutionary and ecological evidence of the phyllodes in *Acacia* was an interesting subject to botanists and foresters. Many authors studied the morphology and development of the seedlings of various species of *Acacia* and discussed the evidence of the juvenile leaves.

Lubbock (1892) described the developmental sequences of juvenile leaves of certain phyllodinous acacia species and noted that the cotyledons are succeeded by a simple pinnate leaf, and that this was followed by a varying number of bipinnate leaves, the petiole gradually becoming more dilated, until at last they developed without any bipinnate leaves on their tips and that these expanded petioles carried on the functions of ordinary leaves.

Cabbage (1915) found the above sequence was maintained in the great majority of cases. However he also found four out of the sixty species examined which produced an opposite pair of simple, pinnate leaves just above the cotyledons. Among these only one species (*A. farnesiana* Willd.) did not belong to Section Phyllodinae (Bentham 1864). Cabbage (1914, 1915, 1928) also found that the number and the form of the transitional bipinnate leaves appearing before the phyllodes

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were not the same in different species but were somewhat consistent within the same species. Some of these results were reviewed and discussed by Fletcher (1921). In recent years very few reports have been published about seedling morphology of the acacias.

Acacia confusa Merr. is cultivated extensively in Taiwan both for soil conservation and timber. The seedling of this species was first described by Keng (1956). He said that the primary leaves succeeding the cotyledons were pinnate but the true leaves produced afterwards were really modified 'phyllodia'. However from Keng's figure the so-called 'primary leaves' were two simply pinnate leaves with two pairs of leaflets on each of them.

Another description was given by Hu (1957). He wrote that the first "true leaf" of *Acacia confusa* is pinnate with 4 leaflets. All the leaves afterwards were phyllodes.

Kuo (1970) observed the seedlings of this species and reported that the "true leaf" is abruptly pinnate and that out of 199 seedlings examined 31 seedlings had two pinnate "true leaves".

Regarding the significance of the first one or two pinnate leaves Cambage (1915) wrote that in the case of *A. leiophylla* which has a pair of pinnate leaves, that although the pair of pinnate leaves appear at the same time, they are unequal in size, as though in some way one had an ascendancy over the other. He also considered that possibly these seedlings with two pinnate leaves represented an older form and that the more recent species have lost one of the pinnate leaves.

MATERIALS AND METHOD

The seedlings investigated in this experiment were raised from open-pollinated seeds collected from the campuses of the National Taiwan University in Taipei and the Tung-Hai University in Taichung. The seeds of thirteen trees were collected separately and pretreated by concentrate sulfuric acid (95.0%) for 2 minutes before sowing. The germinated seeds in the laboratory were then planted in a seedbed.

The number and morphology of the juvenile leaves were carefully investigated and photographed in 1970 and repeated in 1972. Some of the swollen seeds were fixed in Carnoy's fluid and sectioned for examining the developmental pattern of the eophylls.

RESULTS AND DISCUSSION

1. Morphology of normal seedling

a. Cotyledons—two, thick and green in color, oblong with rounded apices, sagitate at base, slightly reflexed when fully expanded, margin entire, glabrous and shiny (Figs. 1-4).

b. First eophyll—even pinnate with 4 leaflets and ending in a point at the apex of the rachis (seta terminalis—Bentham, 1875). Petiole about 5 mm long, purplish-red with a furrow on the upper side, inserted slightly above the node of cotyledons and perpendicular to them. Stipules ovoid, margin irregularly dentate or serrate, less than 1 mm long, very thin, pale green in color (Figs. 1-8).

Leaflets—sessile, oblong, apex mucronate, base unequally rounded; the midrib is nearer the upper margin and divides the leaflets into two unequal parts; there are two secondary veins radiating from the base, one of them extending to the apex,

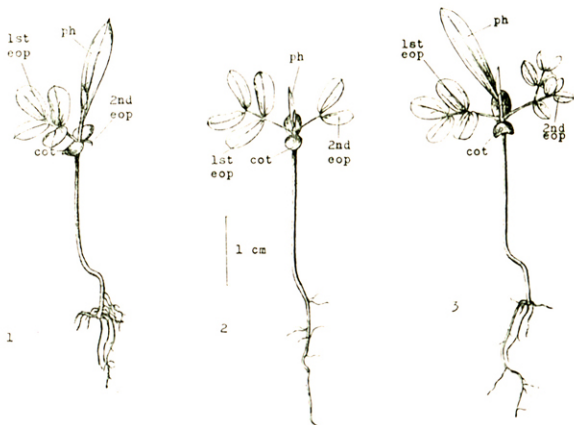


Fig. 1. Normal seedling of *A. confusa*; Fig. 2. and 3. Seedlings with abnormal second eophyll. *cot.*, cotyledon; *1st eop.*, first eophyll; *ph.*, phyllode; *2nd eop.*, second eophyll.

the other only to the middle of the leaflet (Fig. 1-8). The upper pair of leaflets are smaller than the lower pair. The color of the leaflets are usually dark green, sometimes tinged with red.

c. The Second eophyll—which has never been mentioned in previous reports is normally a recurved spur-like point just opposite the first eophyll and almost at the same level. Its maximum length is about 3 mm with a "seat terminalis" at the apex. This seta is incurved at first and recurved when fully developed (Figs. 1, 4, & 14). If the minute stipules were not so prominent on both sides of the base it would hardly be recognized as a modified eophyll. From the position of its stipules it should certainly be considered the second eophyll (Figs. 4 & 14).

From his observations, Cambage (1915) considered that the primitive species of *Acacia* produce two eophylls (as in *A. farnesiana* and *A. leiophylla*) and the more recent species have lost one of the pinnate leaves (eophylls). As seen in this investigation the eophylls of *A. confusa* are actually two, the first one is simply-pinnate and the second one is modified to a small point which perhaps remnant of a pinnate eophyll. If this assumption is true, *A. confusa* should be an advanced species in this vast genus.

d. Phyllodes—The phyllodes are produced immediately succeeding the two eophylls, however the second internode is much longer. *A. confusa* differs from the other species previously reported in that there is no transitional bipinnate leaf on the seedlings examined (Figs. 1, 4, & 7).

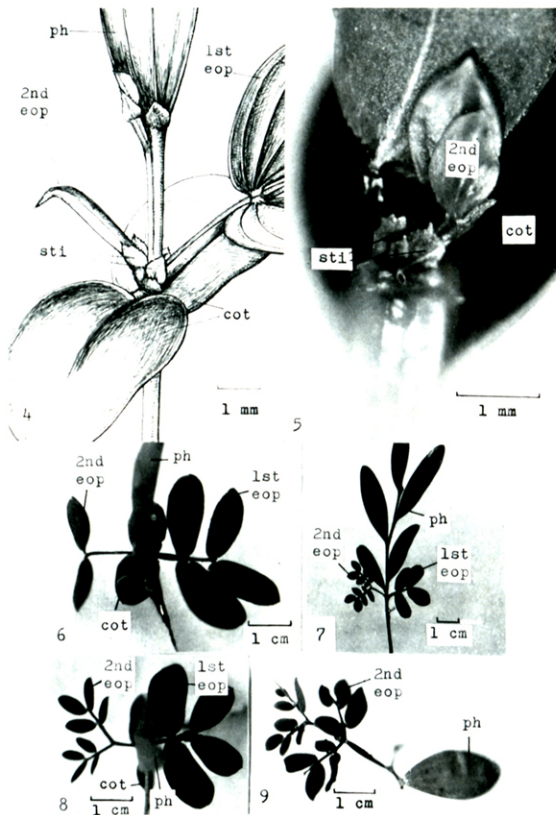


Fig. 4. A sketch of normal seedling; Fig. 5. A plumule in germinating seed with abnormal second eophyll; Fig. 6-9. Abnormal seedlings with various shaped second eophylls. *cot*, cotyledon; *1st eop*, first eophyll; *ph*, phyllode; *2nd eop*, second eophyll; *sti*, stipule.

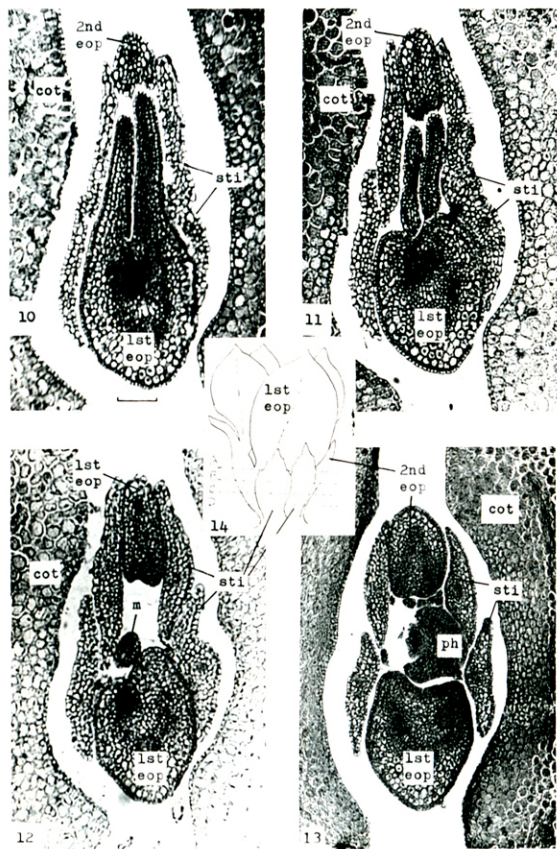


Fig. 10-13. Cross-sections of plumule in germinating seed; Fig. 14. Diagram of a plumule showing the positions A-D of sections in Figs. 10-13 respectively. *cot*, cotyledon; *1st eop*, first eophyll; *m*, meristem; *ph*, phyllole; *2nd eop*, second eophyll; *sti*, stipule.

Transitional bipinnate leaves are believed to be an evolutionary remnant and usually present in many of the advanced species of *Acacia* (Atchison, 1948; Boke 1940, Cambage 1915, 1928, Duke 1965, Fletcher 1921, Keng 1956, Lubbock 1892, Ryder 1954 and Stebbins 1967). It is also believed that those *Acacias* with the bipinnate seedling type of leaves which persist for a long time, are native to regions which are moister than those species in which the reduced type of leaf (phyllode) appear at a relatively early age (Stebbins 1967). From my observations *A. confusa* has no bipinnate at all. This indicates that the origin of this species may have been in a very dry region. In fact, this species is a very drought resistant plant. In other words *A. confusa* may be the most advanced species of this genus.

2. Abnormalities of eophylls

Several seedlings of *A. confusa* produced abnormal eophylls. The following types have been recorded:

A. The first eophyll producing only two leaflets instead of the 4 in normal seedlings.

B. The second eophyll is not modified as a spur-like point:

- 1) The second eophyll is simple-pinnate and produces only two leaflets (Fig. 6).
- 2) The second eophyll is bipinnate and produces four leaflets on each pinna or nearly so (Fig. 8).
- 3) The second eophyll is bipinnate and produces six leaflets on each pinna (Fig. 7).
- 4) The second eophyll is a bipinnate leaf with four pinnae and produces four leaflets on each pinna or nearly so (Fig. 9).

All of these modified second eophylls are recognized not as transitional bipinnate leaves since they are always opposite the normal first eophylls and at very nearly the same level. On the other hand, the phyllodes of this species examined have a 2/5 alternate phyllotaxy. The transitional bipinnate leaves of other species reported by other authors are all alternately arranged on the stem (Cambage 1915, 18, Duke 1965). The pinnate and even bipinnate second eophylls can never be mistaken for transitional forms appearing before the phyllodes.

The frequency of these abnormalities are recorded in Table 1. Only four seedlings out of 117 seedlings produced abnormal first eophylls. Most of the abnormalities occur in the second eophylls, but even here the percentage is small. It is probable that the morphology of the first eophyll in this species is a more fixed character than the second. If those species with only one pinnate leaf (eophyll) have been developed from an older type with two pinnate leaves (eophylls) as assumed by Cambage (1915) then it seems reasonable to expect that the modified second eophylls of *Acacia confusa* will sometimes revert to the original or ancestral type.

3. Morphogenesis of the eophylls

From figures 11-14, it can be seen that the two eophylls of *A. confusa* had been formed in the embryo stage before germination was initiated. The ascending order of the two eophylls in differentiation is also supported by the sections on different levels. It is evident that the form and number of eophylls is controlled by a genetic factor. From figure 5, a 4 leaflet pinnate second eophyll is seen. It is reasonable to believe that the variation of the modified second eophylls is also due to a genetic character and not affected by the environment after seed germination. These variations may indicate evolutionary steps in the reduction of an eophyll to a small prickle from the ancestral form of the pinnate second eophyll.

Table 1. Number and percentage of the seedlings with abnormal eophylls

TREE NO.	TYPES OF EOPHYLLS					
	First eophyll			Second eophyll		
	Normal	Abnormal	%	Normal	Abnormal	%
NTU 1	68	0	0	57	11	19
THU 1	39	0	0	39	0	0
THU 2	47	0	0	42	5	11
THU 3	38	0	0	33	5	13
THU 4	29	0	0	29	0	0
THU 5	21	2	9	20	3	13
THU 6	31	0	0	18	13	42
THU 7	24	1	4	17	8	24
THU 8	32	1	3	24	9	27
THU 9	13	0	0	11	2	15
THU 10	6	0	0	6	0	0
THU 11	22	0	0	19	3	14
THU 12	43	0	0	28	15	35
Total	413	4	1	343	74	18

CONCLUSION

1. The normal seedlings of *Acacia confusa* Merr. produce one even-pinnate first eophyll and a pointed second eophyll. The leaves from the third node and onwards are all reduced to phyllodes. There were no transitional bipinnate leaves observed in this experiment.
2. The morphology of the first eophylls is very stable. In 417 seedlings examined less than 1% of the seedlings had modified first eophylls.
3. About 18% of the seedlings produced modified second eophylls of various forms (mostly pinnate). These abnormalities can probably be considered a reversion to the original types with pinnate second eophylls.
4. From these observation it is reasonable to consider *Acacia confusa* Merr. to be an advanced species of the genus and having originated in a dry region.

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