Morphological Studies on the "Sterile Filaments" in the Androecium of the Peanut Plant, *Arachis hypogaea*, L.*

Kazumi MAEDA

(Faculty of Agriculture, Kōchi University)

Introduction

Already, it has been recognized by several workers²⁾³⁾⁵⁾⁶⁾¹²⁾ that part of stamens composing an androecium of the peanut, *Arachis hypogaea*, L., become abortive. However, we have no literatures dealing with this subject. This paper describes some morphological characters of such so-called "sterile filaments¹²⁾".

Materials and Methods

The pre-germinated seeds of two cultivated varieties, 1) Chiba Chūryū No. 43 (for short "Chiba 43" in the rest) (a large seeded, prostrate, Virginia type) and 2) Celebes (a small seeded, erect, Spanish type) were sown on May 20, 1959, in four wooden frames which were buried under the ground (90×90 cm.) The number of plants per frame was one for Chiba 43 and two for Celebes. Every day during about 100 days after the first day of flowering, microscopic examinations were done, using about 23,000 flowers of both varieties. The malformed flowers, subterranean or cleistgamous flowers and the flowers of which anthesis extremely delayed were excepted from this examination. As the results of continuous picking of flowers and wider spacing for a plant, the very vigorous vegetative growth was observed. The total number of flowers examined per plant showed that the amounts of flower production of both varieties had reached about two~four times of those in the case of practical field conditions (Tab. 1).

Observations and Discussions

I. Androecium The androecium of this plant which has typical papilionaceous corollas (Fig. 1) is enveloped in the keel, and is called the *monadelphous stamens*, commonly. The base of the androecium forms a fleshy tube (staminal tube) and it extends more or less horizontally from the summit of the vertical hypanthium (calyx tube), while the free ends of filaments are reflexed towards the standard¹²⁾ (Fig. 2). This angle which is formed by the staminal tube and the free ends of filaments changes successively, accompanying with the advance of ant-

Tab. 1. Materials and remarks of examination. (1959)

Variety	No. of plants examined	Date of first flowering	Days to flower. from seeding	Duration of examination	No. of days of examin.	Total no. of flowers examin.	Av. no. of flowers examined/pl.
Chiba Chūryū No. 43	2	26/V	36	26/V 3/X	97	18106	9053.0
Celebes	3*	22/V	33	22/V 29/K	98	4922	1640.6

* 1 plant of 4 ones is omitted, since the damage of main stem occurred in the middle of examination.

Fig. 1 a, b. Front view (a) and longitudinal section (b) of fully expanded papilionaceous flower (A. M. 9.00); S, standard; W, wing; K, keel; h, hypanthium (calyx tube); C, calyx. Photographs.

Fig. 2. Androecium 4 hrs. before anthesis (A.M. 2.00); g, globose anther; O, oblong anther; st, stigma; sc, staminal column (staminal tube). Photograph.

thesis (unpublished data). In the flowers having the androecium developed normally, the androecium consists of five filaments with oblong anthers and five filaments with globose anthers. And they are arranged on the staminal tube, alternately (Figs. 2 and 7).

II. Variation of the number of functional stamens To clarify the behavior of the number of sterile filaments (for short "ster. fil." in the rest) in each of the flowers, the variation of the number of functional stamens (for short "funct. st." in the rest) was investigated. These data, which were summarized in Tab. 2, indicate that there are three types of the flowers, respectively, with eight, nine and ten funct. st. in both varieties. At the same time, this fact shows that the number of ster. fil. differs two, one and zero, with different

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Table 2. Varietal difference in the variation on the number of functional stamens. (1959)

Variety	Pl. No.	Number of functional stamens								Total no.of flowers examined
		8		9		10		The others**		
		No.	% *	No.	% *	No.	% *	No.	% *	No.
Chiba chūryū No. 43	1	8615	98.26	147	1.67	4	0.05	2	0.03	8768
	2	9188	98.40	145	1.55	4	0.04	1	0.01	9338
	total	17803	98.32	292	1.79	8	0.04	3	0.03	18106
	Av.	8901.5	98.33	146.0	1.61	4.0	0.04	1.5	0.02	9053.0
Celebes	1	2415	87.38	322	11.72	2	0.07	9	0.03	2748
	2	914	86.64	138	13.08	0	0.00	3	0.28	1055
	3	936	83.65	178	15.91	1	0.08	4	0.36	1119
	total	4265	86.65	638	12.96	3	0.06	16	0.30	4922
	Av.	1421.7	86.68	212.6	12.95	1.0	0.06	5.3	0.31	1640.6

* Per cent. values to the total no. of flowers examined/pl.

** Mainly, consists of flowers with malformed stamens.

flowers, respectively. The flowers with "8 funct. st. and 2 ster. fil." (Figs. 4 b, 5, and 6 a, b) appeared with the highest frequencies (98.3 % in Chiba 43 vs. 86.6 % in Celebes) and nextly, the flowers with "9 funct. st. and 1 ster. fil." (Figs. 4 c, d and 6 c, d) appeared with fairly lower frequencies (1.6 % in Chiba 43 vs. ca. 13 % in Celebes). The evident difference between these values of both varieties, or Virginia type variety and Spanish type one, were noticed. And the flowers with "10 funct. st. and 0 ster. fil." (Figs. 4 a and 7), a "normal" type concerning with the number of stamens, only appeared with very low, almost negligible, frequencies (0.04 % in Chiba 43 vs. 0.06 % in Celebes). As a result of the observation of the relation between the variation of the number of funct. st. and the flowering period, it was known that the successive changes of the occurrence of the flowers with "8 funct. st. and 2 ster. fil." and those with "9 funct. st. and 1 ster. fil." had showed the characteristic varietal difference. These results were indicated in Fig. 3, where the average values which were calculated each ten days were plotted. In Chiba 43, always the flowers with "8 funct. st. and 2 ster. fil." occupied almost all of flowers. On the other hand, in Celebes, the flowers with "9 funct. st. and 1 ster. fil." appeared successively with comparatively higher frequencies (7.0 %~23.4 %) than those of Chiba 43 (0.47 %~4.8 %). And it was noted that the highest frequency had been observed on 40~50 days after the first day of flowering.

The above results seem to indicate that the degree of occurrence of ster. fil. varies with the flower, variety, and flowering period. Accordingly, those may suggest that Celebes possesses more "normal" or prototypical character than Chiba 43, with respect to the completeness of the development of androecium. And also, it is thought that the occurrence of ster. fil. is

Fig. 3. Relationship between the variation of the number of functional stamens and flowering period (1959). (* Av. per cent. values of the numbers of each of the flowers having respectively 8 and 9 functional stamens to the total numbers of flowers examined per plant of each 10 days.)

affected not merely by the genetic factors, but by some physiological and environmental conditions of plants especially during the stamen differentiation period.

III. Types of Androecium Construction (A. C. Types) The above-mentioned relation between the number of funct. st. and that of ster. fil. in each of the flowers was shown in Tab. 3, and the author called it the "Androecium Construction Type". Applying this relation, it was found that the flowers were classified into following four A. C. Types: i) 442-type, ii) 541-type, iii) 451-type, and iv) 550-type. Moreover, it was known that the flowers with "9 funct. st. and 1 ster. fil." consist of two types owing to the difference of the stamen which is in ster. fil. These results were illustrated in Fig. 4a-d. And the frequencies of each of the A. C. Types were shown in Tab. 4.

Further, as shown in last figures, it was con-

firmed that two or one stamens inserted at the vexillar side (opposite the standard) of the staminal tube are usually apt to become the ster. fil. And from the view-point of the order of stamen-arrangement, it was known obviously that one of those ster. fil., S_g is the stamen which ought to grow to the globose anther-stamen, and the other, S_o is the stamen which ought to grow to the oblong anther-stamen, if both ster. fil. developed normally (Figs. 4 b-d, 5, 6 a-d, and 7).

Tab. 3. The "Androecium Construction Types" and the relation between the no. of functional stamens distinguished the 2 anther types and the no. of sterile filaments in each of the flowers.

No. of functional stamens	Androecium Const. type	No. of functional st.		No. of sterile fil.
		Globose anther-stamen	Oblong anther-stamen	
8	442-	4	4	2
9	{541- 451-	5	4	1
10	550-	5	5	0

Fig. 4 a-d. Diagrammatic figures showing 4 Androecium Construction Types; a) g_1 - g_5 , globose anther-stamens; o_1 - o_5 , oblong anther-stamens; b, c, and d) S_g , sterile fil. which ought to grow into the globose anther-stamen, g_1 ; S_o , sterile fil. which ought to grow into the oblong anther-stamen, o_5 . Fig. 5. Two ster. fil., S_g and S_o . Microphoto. ca. 17 $\times$. Fig. 6 a-d. Various appearances of the 3 stamens inserted at the vexillar side of the staminal tube; O_n , oblong anther-stamen almost normally developed; O_i , oblong anther-stamen insufficiently developed; N_o , normal oblong anther-stamen. a, b, ca. 14 $\times$ c-d, photo. ca. 6 $\times$. Fig. 7. Androecium with 10 funct. st. Showed the staminal tube artificially expanded., Photo. ca. 5.6 $\times$, st, stigma. Fig. 8. Sterile fil., S_g . Microphoto. ca. 36 $\times$.

photo. ca. 6 $\times$. Fig. 7. Androecium with 10 funct. st. Showed the staminal tube artificially expanded., Photo. ca. 5.6 $\times$, st, stigma. Fig. 8. Sterile fil., S_g . Microphoto. ca. 36 $\times$.

Among the three stamens (g_1 , o_1 , and o_5), inserted at the vexillar side both oblong anther-stamen, o_1 and o_5 showed the ratio approximate to 1:1 in frequency to become the ster. fil., therefore, it may be said that both stamens have almost equally a possibility to become ster. fil. and that it is decided randomly, whether to do so or not. Anthers of both oblong anther-stamens developed normally are usually uniloculate* against the other three oblong anthers are biloculate, in addition, the former differs with the latter in the tendency of the distribution of the anther length (data were omitted).

Accordingly, it may be said that the former have peculiar nature against the oblong anther-stamen, o_2 , o_3 , and o_4 (Fig. 4a). The data, which were shown in Tab. 4, seem to indicate that the stamen g_1 has almost lost to develop into functional one, in other words, it has almost degenerated (Fig. 8).

* First noted by Hammon (from SMITH¹²).

IV. "Monadelphous" stamens and "Diadelphous" stamens *Crotalaria spectabilis*, a member of the Papilionatae in common with the peanut, is one of the species having the *diadelphous* stamens. This *diadelphous* stamens (Fig. 9) is analogous to the *monadelphous* stamens of the peanut in following two respects: i) dimorphism in anther types (globose and oblong anthers), ii) the alternate arrangement of the anthers of two types on the staminal tube. However, in the former, nine funct. st. unite in one staminal bundle and the rest one "solitary stamen" (G_s) is free from the staminal bundle. This solitary stamen bears the globose anther as may be expected by the site in the stamen-arrangement. Furthermore, by a comparison of both types of the androecium, the author found that the site of ster. fil., S_g (Figs. 4 b, c and 8) of the androecium of the peanut corresponds to that of solitary stamen of the androecium of *Crotalaria spectabilis*.

Tab. 4. Varietal difference among the frequencies of occurrence of each Androecium Const. Types.

Variety	A.C. Type	Frequency %*
Chiba chūryū No. 43	442-	86.68
	541-	12.86
	451-	0.09
	550-	0.06
Celebes	442-	98.33
	541-	1.59
	451-	0.02
	550-	0.04

* Per cent. value to the total no. of flowers examined.

In the Papilionatae, the species having the *monadelphous stamens* like the peanut are rather rare than the species having the *diadelphous stamens* like *C. spectabilis*. The more investigations on the morphological relations between both types of androecium may give somewhat suggestions to the consideration of the occurrence of the ster. fil. in the peanut.

V. On some recent descriptions dealing with the number of stamens of the peanut

Some disagreements are found among the recent descriptions of the number of stamens of this plant.

MAKINO, et al.⁷⁾ described: "...stamens 8...". SHIBUYA¹⁰⁾, and other workers: NAGAI⁸⁾, SHISA et al.¹¹⁾, NISHIKAWA et al.⁹⁾, TOGARI et al.¹³⁾: have described that stamens are 10. None of them mentioned the occurrence of ster. fil. of this plant. In our country, EHARA²⁾ alone described that two stamens to be sterile, but he did not refer to that details.

SMITH¹²⁾ stated that "In all species and varieties observed, the androecium consists of eight functional stamens and two sterile filaments. The latter are always found inserted opposite the standard." Also, GREGORY et al.³⁾ noted that "The staminal column is usually composed of ten filaments, eight of which are normally anther bearing." BAILEY¹⁾ described in the Manual of Cultivated Plants: "*Arachis*, L. ... stamens 9 and 1, diadelphous or sometimes 9 and monadelphous..." HERMANN⁵⁾ described in his contribution, A Synopsis of the Genus *Arachis*, that "...Generic Description...stamens 10 or, less frequently, 9, monadelphous, the vexillar stamen sometimes aborted;...", and on *Arachis guaranitica*, one of wild species of this genus, "...stamens 9, with glabrous filaments, 5 with globular anthers borne on longer filaments and 4 with oblong anthers borne on shorter filaments;..." To BAILEY's description, SMITH¹²⁾ mentioned that "The writer has not observed any inflorescences with.....nor has he found evidence of the diadelphous stamens which BAILEY attribute to the genus." According to GREGORY⁴⁾, the

Fig. 9 a, b. Diagrammatic figure (a) and photograph (b) of "Diadelphous" stamens of *Crotalaria spectabilis*, especially showed the solitary stamen, G_s : a) g_1 -5, globose anther-stamens; O_1 -5, oblong anther-stamens.

species *Arachis guaranitica* was collected only once in the late 19th century by HASSLER, and it was not seen again until 1959 when GREGORY collected it himself some miles last of the type location over the border into Brazil. Further, he stated, "...therefore, any observations that HERMANN made would be of the most meager nature and not to be relied upon. HERMANN's treatment of the taxonomic questions on *Arachis* is also unacceptable."

Thus, there are some doubts about both of BAILEY's and HERMANN's descriptions, however, none of them do make any mention of the variability of the number of ster. fil. and the varietal difference in it. At any rate, it is probable that the disagreements among the some descriptions on the number of stamens of the peanut were caused by the existence of the flowers having different numbers of ster. fil. as stated in this paper.

Now, it may be said that the occurrence of ster. fil. is one of the botanical characteristics of this species, and we should pay attention to the difference of its degrees among different flowers, varieties, and flowering periods, in connection to the practical castration treatment in crossing of this plants.

The varietal difference among the degrees of occurrence of ster. fil. in this plant, may be useful to the investigation of the problems on the geographic distribution and differentiation of races or cultivated varieties of *Arachis hypogaea* L.. And it seems to be of interest to examine the occurrence of the ster. fil. for the wild species of this genus, in connection to the research of the relation to the cultivated species, *A. hypogaea* L..

From these standpoints, the author made this year the investigation on this subject, using about 130 foreign and 20 Japanese peanut varieties. Those results obtained will be presented next time.

Summary

To clarify the morphological characters and the behavior of the no. of "sterile filaments"

in the androecium of the peanut, microscopic observations were done, using about 23,000 flowers of two varieties, Chiba Chūryū No. 43 (Virginia type) and Celebes (Spanish type), every day during about 100 days after the beginning of flowering.

Among 3 stamens inserted opposite the standard, one stamen, the nearest the standard, and either of two stamens adjacent to the former are apt to become the ster. fil. And the latter sometimes develop normally more frequently than the former. Thus, the no. of ster. fil. in each of the flowers differ with different flowers, from 2 to 0, at the same time, the no. of functional stamens varies from 8 to 10. The frequency values of the each of the flowers having 8, 9, and 10 functional stamens of both varieties are as follow (per cent. values to total no. of flowers examined/pl.): 98.3%, 1.6%, and 0.04% in Chiba Chūryū No. 43 vs. 86.6%, ca. 13%, and 0.06% in Celebes, respectively. Especially, it was noticed that the flowers having 10 functional stamens, which is a normal type concerning to the completeness of development of the androecium, only appeared with almost negligible, low frequencies. In the relation between the successive changes of these frequencies and the flowering period, the same varietal difference was clearly observed.

Generally, it was considered that the occurrence of sterile filaments in the peanut are affected not only by the genetic factors, but by the certain physiological and environmental conditions of plants, especially during the stamen differentiation period.

Some disagreements among recent descriptions dealing with the no. of stamens of this species are probably caused by the fact that the degree of occurrence of sterile filaments differ with different flowers, varieties, and flowering period.

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〔和 文 摘 要〕

落花生における“Sterile filaments”の発生について

前 田 和 美

(高知大学農学部)

落花生の雄ずい筒の特定位置に発生する, “sterile filaments”の形態的性状と, その発生程度の品種や開花時期による差異をみるため, 開花始から約 100 日間, 千葉中粒 43 号, セレベスの二品種, 約 23,000 の花について調査を行なった。

1 雄ずい群内の, 正常雄ずい (f. st.) と “sterile filaments” (ster. fil.) との数的関係からみると, 両品種ともに “8 f. sf. + 2 ster. fil.” の花が最も優勢な出現をみたが, その頻度は, ついで多く出現する “9 f. st. + 1 ster. fil.” の花の頻度に支配され, 最も正常な型というべき, “10 f. st. + 0 ster. fil.” の花はほとんど無視できる程度の出現をみたにすぎない (Tab. 2)。また, それぞれの花の出現頻度間に相当顕著な品種間差異を認めたが, それらの時期的変化においても同様な品種的特性を認めた (Fig. 3)。かかる本種における ster. fil. の発生は, 品種のみならず, 特に雄ずい分化期における植物の生理的, 環境的条件にも影響されることがうかがわれ, これがまた, 従来の記載における本種の雄ずい数の相違の一因となつてゐることが推察された。