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Notes on Articulated Coralline Algae from Korea 1. Genus *Marginisporum* (Corallinales, Rhodophyta) in Cheju Island

Ki Wan LEE

Department of Marine Biology, College of Ocean Science,
Cheju National University, Cheju 690-756

한국산 유절 산호조에 관한 소고* 1. 제주도산 게발혹속 (산호조목, 홍조식물문)

이 기 완

제주대학교 해양과학대학 증식학과
제주도 제주시 690-756

Key words : Coralline algae, Korea, Taxonomy, *Marginisporum*, Rhodophyta, Corallinales.

Two species of coralline algae, *Marginisporum crassissimum* and *M. aberrans*, from Cheju Island were examined anatomically specially referred to seven morphological characters; number of tiers, height of tiers, intergenicula axis, maximum and minimum width of intergenicula, and kind and number of conceptacles. Species of *Marginisporum* showing apical conceptacle as well as marginal and lateral conceptacles and fitting the current concept of genus *Marginisporum*. Thus the two species investigated were well included in the genus.

INTRODUCTION

The articulated coralline genus *Marginisporum*, Corallinoideae, Corallinales, is a prominent component of the algal flora in Cheju Island, Korea. The genus is characterized by the type of conceptacles among the Corallineae possessing medullary filament line (Ganesan, 1968; Johansen, 1969, 1981; Segawa, 1941 a, b). It appears to be endemic to the orient (Masaki et al., 1982; Yendo, 1905). *Marginisporum* is one of the six genera of articulated corallines known to occur in Cheju Island.

Because of the unique position of Cheju Island in warm current about 40㎞ off the southern coast of Korea in the Yellow Sea (Byun et al., 1983; Rho, 1974, 1985; Rho and Chung, 1975, 1976, 1977, 1980), an understanding of the marine biota will allow for a better interpretation of marine biogeography in the orient. It will be especially

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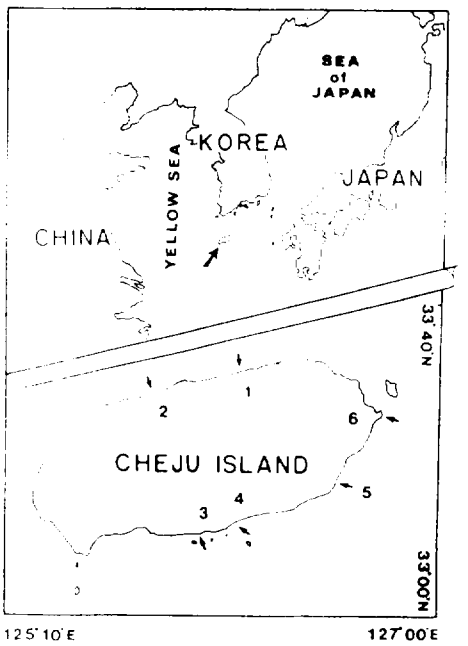

Fig. 1. A map of Cheju Island. Numbers indicate sampling sites : 1. Kimnyeong, 2. Donggwi, 3. Kangjŏng, 4. Sŏgwi, 5. Pyosŏn, 6. Sŏngsan.

important to compare the algae of Cheju Island with those along the shore of mainland, Korea, Japan and China.

Since the first algal floristic record by Kang (1960) a few studies of the algae of Cheju Island have been published (Lee, 1974, 1976; Lee and Lee, 1976, 1982), but information on the algae at this strategic locality is sparse. No data on articulated corallines in Cheju Island other than check list are available (Kang, 1966). In addition to *Marginisporum*, species of *Jania*, *Calliarthron*, *Yamadaea*, *Corallina*, and *Amphiroa* also occur commonly in this Island. The present paper for the first step deals with the articulated corallines in Cheju, sourthern Korea.

Species that are currently placed in *Marginisporum* were first described by Yendo (1902a) as *Amphiroa declinata*, *A. crassissima* and *A. aberrans*. Shortly thereafter he (Yendo, 1902b) used the name *Marginisporum* for the first time, giving it as a subgenus under the genus *Amphiroa* and including two of the three species he had named earlier : *A. crassissima* and *A. declinata*. He (1902b) included *A. aberrans* as the sole species in another new subgenus *Pseudoarthrocardia* under genus *Amphiroa*. However, he gave no diagnosis to the both of these two genera. Weber-van Bosse (1904) shuffled Yendo's species about, placing *A. declinata* in the genus *Arthrocardia* and sugesting that *A. crassissima* also belongs to the latter genus. Seemingly ignoring Weber-van Bosse's conclusion, Yendo (1905) treated *Marginisporum* as a section of the genus *Amphiroa*, and included there again *A. crassissima* and *A. declinata*, while he placed *A. aberrans* in *Amphiroa* section *Arthrocardia* (Yendo, 1905). Ganesan (1968) elevated *Marginisporum* to the status of genus, including *M. crassissimum* (Yendo) Ganesan and *M. declinata* (Yendo) Ganesan. Finally Johansen (1969) added *M. aberrans* (Yendo) Johansen *et* Chihara to the genus.

These three species have been recorded in numerous publications (Fujita, 1984; Masaki *et al.* 1982; Murata and Masaki, 1978; Noda, 1970) from Japan, although *M. declinata* appears to be rare. *M. aberrans* and *M. crassissimum* have been reported from Korea (Kang and Lee, 1986; Kim *et al.*, 1986; Nam, 1986; Song, 1986).

In the present paper two species of *Marginisporum* from Cheju Island, *M. crassissimum* and *M. aberrans*, are considered in detail. They are included among an estimated 17 species of articulated corallines from this island.

MATERIALS AND METHODS

Collections of articulated corallines were collected at six sites in Cheju Island (Fig. 1) by the first author from June to October, 1986. The specimens were preserved in 5% formalin/seawater solution. Most studies were made on specimens that had been sectioned and stained. After decalcification in 5% trichloroacetic acid portions to be sectioned were dehydrated, embedded in paraffin, sectioned at 6-8μm, stained in Delafield's hematoxylin, and prepared for viewing. Anatomical morphology and quantitative analysis were performed by seven characters; minimum and maximum width of intergenicula, intergenicula length in long axis as shown in Fig. 2, kind and number of conceptacles as shown in Fig. 3 and Fig. 4, tier number of medullary cells, and height of tier of medullary cells by calculation of total tier numbers per intergeniculum length in long axis. Illustrations were made using a drawing tube on a wild microscope and photomicrography.

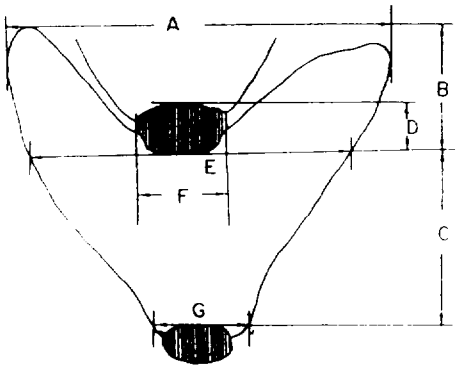

Fig. 2. Diagram of generalized intergeniculum of *Marginisporum* how measurements were derived.
A=maximum width of intergeniculum;
B=lobe height (not used);
C=intergeniculum length long axis;
D=geniculum length (not used);
E=(not used); F=geniculum width (not used);
G=minimum width of intergeniculum.

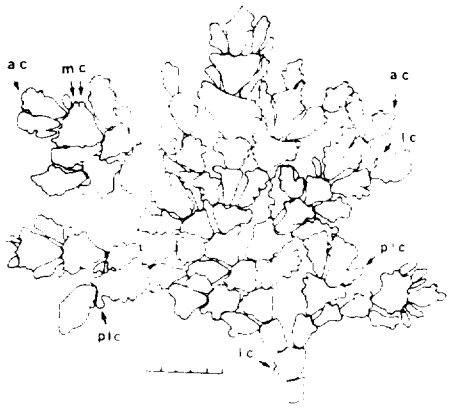

Fig. 3. Upper surface of part of a frond of *Marginisporum crassissimum*, showing location of conceptacles. ac=axial conceptacle;
mc=marginal conceptacle;
lc=lateral conceptacle;
plc=pseudolateral conceptacle. Scales; *mm*.

Fig. 4. Upper surface of part of a frond of *Marginisporum aberrans* showing location of conceptacles. Scales; *mm*. Abbreviations same as in Fig. 3.

Table 1. Diagnostic characteristics of the genera of the Corallinoideae

Species	Habitat	Frond height (㎝)	Branching	Intergenicular	Conceptacles (№)	Additional References
Corallina Linne, 1758	epilithic	3~10	Pinnate, erect	compressed, (sub-) cylindrical	axial in origin	Manza (1940)
Arthrocardia Decaisne, 1842	epilithic	2~ 6	pinnate, cymoide, erect	pinnate, cymoide	axial in orign (embeded)	Johansen (1971) Ganesan (1967) Manza (1940)
Calliarthron Manza, 1937	epilithic	5~10	dichotomous, pinnate	cylindrical, or compressed	marginal & lateral in origin (embeded) [(1) 2-4 (6)]	Johansen (1969) Manza (1940, 1968)
Yamadaea Segawa, 1955	epilithic	less than 2㎝	rare erect	1 or 2 intergenicula	axial 1/intergenicula	Dawson & Steel (1964)
Bossiella Silva, 1957	epilithic or on shell	2~10.5	pinnate, dichotomous, or mixed, erect	cylindrical, or compressed, possess midrib	lateral (2-4 (6))	Johansen (1971) Manza (1940)
Serraticardia Silva, 1957	epilithic	2~10	(bi-) pinnale, or dicholomous	flatten, compressed, (sub-) cylindrical	axial & marginal (usually paired)	Johansen (198) Yendo (1905)
Chiharaea Johansen, 1966	epilithic	0.4	flatten recumbent	flatten, subcylindrical	axial & marginal (pores ecentric) (embeded) 1-3/intergenicula	Johansen (1971) Segawa (1941)
Marginisporum Ganesan, 1967	epilithic	4~20	irregular	compressed or flatten, cylindrical	see Table 2	Yendo (1902, 1904) Segawa (1941)
Alatocladia Johansen, 1969	epilithic	5	irregular	compressed, cylindrical (lobe-like projection)	axial and marginal in origin	Segawa (1949)

The specimens were deposited at Cheju National University and at Clark University (CHU).

RESULTS

Species examined are well fitted to the current concept (Johansen, 1981) of genus *Marginisporum*. They possessed mainly marginal and lateral conceptacles (Table 2; Fig. 3, 4) as well as apical and pseudolateral ones, and consisted with straight medullary filaments (Pl. Ⅰ, Ⅱ).

For the identification of intraspecific, seven morphological characters are adapted. Figures 5 and 6 are the results summarized. Frond appearance of *M. crassissimum* shows scutiform intergenicula because of possess-

Table 2. Conceptacle types in the two species of *Marginisporum* in Cheju Island

Conceptacles	*M. crassissimum*	*M. abberrans*
Axial	38 (3%)	32 (3%)
Marginal	1,293 (85%)	139 (13%)
Pseudolateral	24 (2%)	10 (1%)
Lateral	144 (1%)	912 (83%)
Total Conceptacles	1,499 (100%)	1,093 (100%)
Mean № conceptacles per intergeniculum	3.57 (± 1.95)	4.62 (2.54)

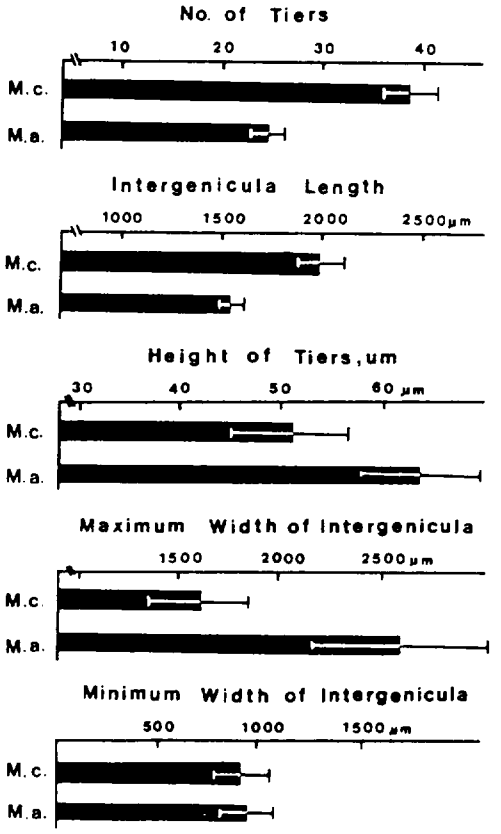

Fig. 5. Graphs comparing five characters in *Marginisporum crassissimum* (M. c.) and *M. aberrans* (M. a.) : number of tiers of medullary cells per intergeniculum, lengths of intergenicula, height of tiers of medullary cells, maximum and minimum width of intergenicula.

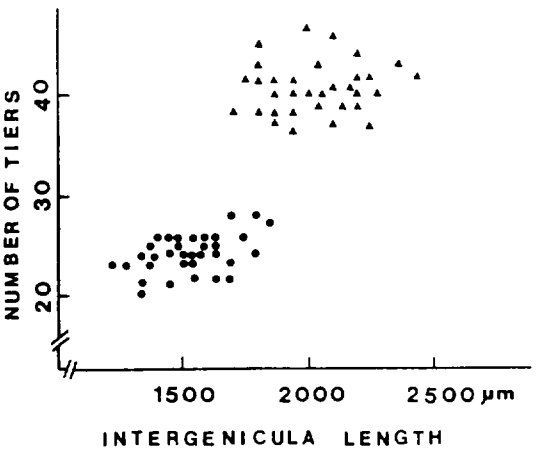

Fig. 6. Two characters, the number of tiers of medullary cells per intergeniculum and intergenicula length, plotted for *Marginisporum crassissimum* (triangles) and *M. aberrans* (circled) with ten different fronds for each collection at same site, Pyoson.

ing many tiers (+48%) and longer (+30%) intergenicula than those of *M. aberrans* (Fig. 3). On the other hand *M. aberrans* shows a typical obtrapezoidal shape because of possessing broader (+38%) maximum width of intergenicula than those of *M. crassissimum* (Fig. 4). Another obtained results in Figure 5, exhibit different results from four morphological characters between two species except those of one. Table 3 is a result on covariance of analysis for regression coefficient between two morphological characters, maximum and minimum width of intergenicula. The both species show significant regression coefficient ($F = 26.966$, $df = 1.60$).

Genus *Marginisporum* (Yendo) Ganesan 1968

Synonym : *Amphiroa* subgen. *Marginisporum* Yendo 1902a

Amphiroa sect. *Marginisporum* Yendo 1905

Type species : *Marginisporum crassissimum* (Yendo) Ganesan

Basionym : *Amphiroa crassissima* Yendo 1902a

Description : Frond epilithic, aggregated, erect, 5-12 cm high, branching pinnate, dichotomous or irregular; intergenicula of main branches near base cylindrical, in upper parts compressed, lobed, and /or winged, scutiform; medullary cells straight; conceptacles marginal, lateral, or axial in origin,

Table 3. Covariance analysis for regression coefficient between two morphological characters maximum and minimum width of intergeniculum, in two species of *Marginisporum* from Cheju Island.

	*PSC 17	*PSC 06	Within	Regression Coefficient	Common	Adjust Mean	Total
N	32	32			64		64
F	31	31			62		63
Σx^2	22591546.9	8205621.87			33797168.7		45123393.7
Σy^2	330458.87	2632246.87			4936793.74		4985193.75
Σxy	-169549.86	3565340.62			1699393.74		2732093.7
Regression Coefficient	-0.071	0.042					
f	30	30	60	1	61	1	62
Deviation from Regression	$\Sigma y^2-(\Sigma xy)^2/\Sigma x^2$	2190386.23	1134808.52	3325194.75	1494455.21	4819649.96	123.25	4819773.21
	Mean Square			55419.91		79013.66		

$F'_{0.05}$ = 26.966 $F_{0.05}$ (0.01) = 7.08

$F'_{0.01}$ = 0.002 $F_{0.05}$ (0.05) = 4.00

*PSC : Coralline samples (C) collected at Pyoson (PS)

mostly originating in terminal intergenicula, one to several conceptacles in each fertile intergeniculum.

Key to the species of Cheju Island

1. Most intergenicula of upper part are scutiform or obtrapezoidal, and marginal concpetacles are prominent on the side of intergenicula ..... *M. crassissimum*
1. Most intergenicula of upper part are lobed or winged, and lateral conceptacles are prominent on the surface of intergenicula ..... *M. aberrans*

Marginisporum crassissimum (Yendo) Ganesan 1968 (Fig. 3, Pl. 1)

Basionym : *Amphiroa crassissima* Yendo 1902a

Frond thick, in basal part terete or cylindrical, upper compressed, 5-8cm high, overlapping upwards caused by wide spreading; branching di-(or tri-)chotomous, irregulary pinnate; intergenicula ovoidal clavate to sagittate in apex, scutiform to obtrapezoidal in upper, scutiform to compressed cylindrical, sometimes costate in middle, cylindrical in lower; medullary cells straight; tier with same size; conceptacles marginal mainly, sometimes lateral of axial, (1)2-6 conceptacles on intergenicula.

Habitat : Growing on rocks in lowest littoral zone.

Specimens examined : PSC17, GJC05, SGC07, DGC01, DGC07, SGC05, KNC08, KNC03, KNC05, SSC04.

Marginisporum aberrans (Yendo) Johansen *et* Chihara *in* Johansen 1969 (Fig. 4, Pl. 2)

Basionym : *Amphiroa aberrans* Yendo 1902a

Synonym : *Arthrocardia aberrans* (Yendo) Weber-van Bosse 1904

Frond large, in basal portion terete, subterete or cylindrical, upper compressed, 7-12㎝ high; branching di-(or tri-)chotomous irregulary pinnate; intergenicular flatten in apex, lobe to winglike in upper, median coastate but not clear; terete to subterete in middle; conceptacles lateral mainly, sometimes marginal, axial, or pseudolateral, 2-8 (12) on intergeniculum.

Habitat : Growing on rocks in upper part of sublittoral zone.

Specimens examined : PSC06-08, SGC05, GJC06, KNC07, SSC05.

DISCUSSION

The vegetative tissues and general aspects of the fronds of *Marginisporum* are similar to those of *Bossiella* (Johansen, 1972; Manza, 1940; Silva, 1975), *Arthrocardia* (Decaisne, 1842; Ganesan, 1968a, Johansen, 1972; Manza, 1940), and *Serraticardia* (Ganesan, 1968b; Silva, 1957). The frond structure also shows a resemblence to that of *Calliarthron* (Johanson, 1969; Manza, 1937, 1940), but the medullary cells of intergenicula are strikingly different in that *Marginisporum* has straight filaments while *Calliarthron* interlaced ones (Johansen, 1969; Akioka *et al.*, 1981). In *Corallina* (Baba *et al.*, 1988; Manza, 1940) the frond consists of relatively smaller intergenicula which are not so compressed as those of *Marginisporum*, *Yamadaea* (Dawson and Steel, 1964; Segawa, 1955) and *Chiharaea* (Johansen, 1966, 1972) are unique by virtue of small size of the frond (Johansen, 1981). Thus based in vegetative features, the genera *Bossiella*, *Serraticardia*, *Arthrocardia* and *Marginisporum* appear to form complex somewhat remote from the other genera in the Corallinoideae, tribe Corallineae (Johansen, 1981).

The genus *Marginisporum* can satisfactorily be segregated from *Bossiella*, *Serraticardia*, and *Arthrocardia* only by the site of the origin of tetrasporangial (or bisporangial) conceptacles (Table 1). Axial and marginal conceptacles originate in meristematic medullary tissue ar or near apices; lateral (or cortical) conceptacles originate in cortical meristems on intergenicula surface (Johansen, 1981). An axial conceptacle originates in line with the geniculum subtending the fertile intergeniculum.

In Korea *Marginisporum* seems to occur most prominently at Cheju Island where it has been reported several times (Kang, 1960, 1966; Lee, 1974, 1976; Lee and Lee, 1976, 1982). It is noticeable that the genus not appear in some recent floristic and ecological studies from the west coast, e.g., Kyeonggi Bay (Lee and Lee 1981), Muchangpo (Kim and Lee 1985), from the south coast, e.g., Kwang Yang Bay (Lee and Kim, 1977), Samchonpo (Kim *et al.*, 1986). Yoo and Lee (1980) barely mentioned *Marginisporum aberrans* (as *Amphiroa aberrans*) from the south coast. The distribution of *Marginisporum* is in contrast to that of *Bossiella* (especially *B. cretacea*) which requires colder water. Most species of *Amphiroa* needs warmer water (Masaki *et al.*, 1982). *Corallina* is relatively eurythermal and occurs in colder as well as warmer water, compared with *Marginisporum*.

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적 요

제주산 유절산호조로서 7가지의 형태적 특징 (number of tiers, height of intergenicula, height of tier, maximum and minimum width of intergenicula, kind and number of conceptacles)을 해부학적으로 검토하여 둘레게발혹(*Marginisporum crassissimum*)과 방황게발혹(*M. aberrans*)의 두종을 동정하였다. 이들 유절산호조들은 연변(marginal) 생식소 뿐만 아니라 정단(apical) 및 피층(lateral or cortical) 생식소도 있었으나 다른 형태적 특색은 게발혹속(genus *Marginisporum*)의 최근 분류 개념에 잘 일치한다.

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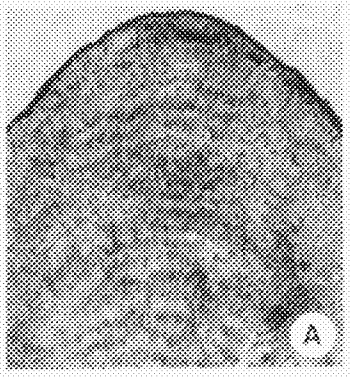
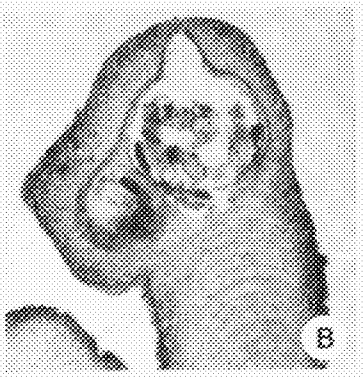
EXPLANATION OF PLATES

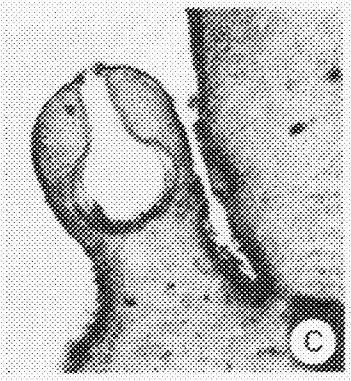
Plate Ⅰ. *Marginisporum aberrans* Yendo.
A. longisection through apex of branch; B. axial conceptacles;
C. pseudolateral conceptacles; D. axial(ac) and marginal(mc) conceptacles;
E. fused tetrasporangial conceptacles; F. lateral conceptacle.

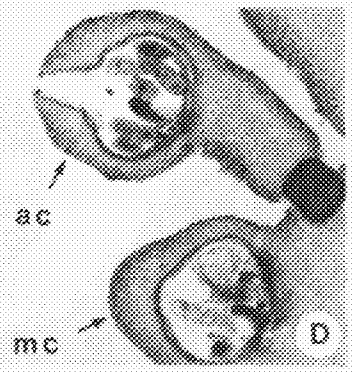
Plate. Ⅱ. *Marginisporum crassissimum* (Yendo) Ganesan.
A. young tetrasporangial conceptacles; B. tetrasporangial con ceptacles containing young tetrasporangium and surmounted by a cap; C. tetrasporangial conceptacles containing variously aged tetrasporangia. N=nucleus, yt=young tetrasporangia;
D. male conceptacles; E. lateral conceptacles(male); F. marginal conceptacles;
G. longisection through intergenicula tissue showing secondary cortex(sc);
H-Ⅰ. senescent conceptacles into which secondary tissues have grown.

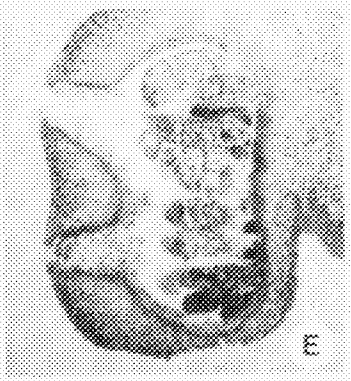
PLATE I











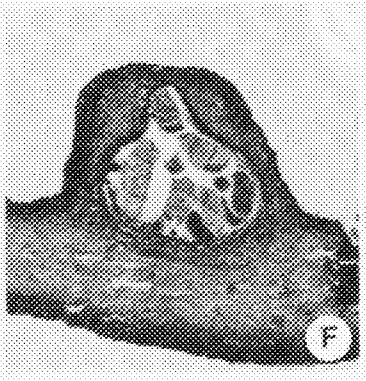


PLATE II