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The Determination of the Ages of Cod from Otoliths Collected in NAFO Divisions 2J, 3K and 3L

by

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Introduction

Except for laboratory-reared specimens, it is perhaps impossible to determine with certainty the age in years of individual cod. Cod taken in the commercial fisheries in the Northwest Atlantic are usually of age four and older and may include a dozen or more age groups (ICNAF Sampling Yearbooks). As cod become older and the average length-at-age tends towards a maximum, the overlap in length range of adjacent age groups becomes more pronounced. The proportion of cod of a particular age at a given length group varies because of factors such as growth rate changes and fluctuations in year-class strengths. It would appear, therefore, that the lengths of specimens taken in the commercial fisheries do not provide a reliable indication of ages.

Ages of cod have been determined from various skeletal elements but interpretation of age from otoliths is usual. In recent years variation in the interpretation of ages of cod from otoliths by readers from various countries become apparent within ICNAF. In an attempt to resolve these discrepancies and to provide guidelines for interpretation, workshops organized by ICNAF were held in Vigo in October, 1975 (Lopez-Veiga et al 1977) and in St. John's in February, 1977 (Anon 1977).

From the St. John's Workshop, photographs were available of 224 otolith sections for which agreed ages had been determined by the participants. A selection of these photographs is presented here together with comments as to how the various structures in the sections were interpreted. All photographs were of otolith halves under a constant magnification.

Procedure for Interpreting Age from Cod Otoliths

Although more sophisticated methods are available, the following procedure has been found acceptable in some laboratories.

(a) Preparation of the otoliths

The otoliths are stored dry after removed from the fish. The otolith is cut across the sulcus acousticus with a scalpel (see photographs). If the cut is not made correctly, the aspect of the annuli on the cut surface changes and an error in ageing may result. The otolith halves are embedded in moddelling clay.

(b) Microscopic examination

The otolith halves are examined by transmitted light under low power (say about 15X) by means of a binocular microscope. The amount of illumination should be adequate to distinguish relevant details. The angle of illumination may be at about 45 degrees. The light is shaded by means of a scalpel from

direct illumination of the cut surface of the otolith halve. A few drops of alcohol on the cut surface is helpful. Otoliths examined in this way appear as in the accompanying photographs.

(c) Interpretation of age

Opague and hyaline rings may be distinguished on the otolith section. Opague rings are associated with periods of fast growth in the fish and usually are deposited in the otolith in summer and fall. Hyaline rings are usually deposited in winter and spring. Over a period of one year, it would be expected that one opague and one hyaline ring could be deposited in the otolith. In practical terms, the number of hyaline rings is the same as the age if the fish's birthday has been reached, and all the hyaline rings are annuli.

The fish's birthday. Since the actual birthday of the sampled specimen is unknown, an arbitrary birthday of January 1 is convenient. The relationship between the number of hyaline rings and the fish's age at capture might be as follows:

Period	Number of hyaline rings	Number of opaque rings	Edge of otolith	Age in years
Jan-Aug	4	4	Hyaline	4
Apr-Aug	4	5	Opaque	4
Sep-Dec	5	5	Narrow hyaline	4

It is usual that otoliths of younger cod show new opaque growth earlier in the summer and new hyaline growth earlier in the autumn than older cod. It is in the autumn that difficulties arise in determining the age from the number of hyaline rings. Thus, if the hyaline zone at the edge of the otolith was formed in the previous winter, the age equals the number of hyaline rings. If, on the other hand, the hyaline zone at the edge was only recently formed, it is not counted in determining the age.

Checks and splits. Unfortunately, not all hyaline rings are annuli. A check is a hyaline ring in the middle of an opaque zone and should not be interpreted as an annual winter ring or annulus. A split is a composite hyaline ring consisting of two or more closely spaced hyaline rings of the same pattern which comprise one annulus. Also, some hyaline rings are not well defined, and it may sometimes be difficult to determine if a particular hyaline ring is in fact an annulus.

Patterns in the annuli. Since the past history of the fish from which the otolith was taken is unknown, it is reasonable to assume that its growth is in accord with the von Bertalanffy growth pattern,that is, a series of rapidly decreasing increments follows the first few years of rapid growth. Therefore, if a relationship between fish length and otolith radius is accepted, the pattern of the annuli along a line from the center of the otolith section toward the periphery will be a series of progressively declining increments. If such a pattern exists and can be readily discerned, the problem of distinguishing checks and splits will be very much lessened.

Use of otolith size or fish length. In Div. 2J, 3K and 3L, the size ranges of cod by age-group taken in the commercial fishery overlap to such an extent that the use of fish length or otolith radius is not a reliable indicator of age, and, if used in conjunction with an interpretation of the otolith patterns, may in fact be a source of bias.

Use of constant magnification. Despite overlap in the otolith radius of different age-groups, it is clear that, on the average, the otolith radius increases with age. The fact that many expert otolith readers not only maintain a fixed magnification but also a preferred microscope when interpreting otoliths implies that otolith size assists the reader in determining the age.

Validation of ages. It is presumably not possible to know with certainty the age of an individual cod of commercial size when it is taken from the wild. Confidence can be gained that otoliths are being consistantly interpreted if, over a period of a few years, dominant year-classes persist and growth within the year-classes is positive. A comparison of age compositions of age compositions and growth rates for cod of a particular stock as supplied to NAFO would indicate whether there were substantial discrepancies or biases. Occasional otolith exchanges within a laboratory or between laboratories may act as a safeguard against overconfidence.

Photographs Showing how Ages were Interpreted

The photographs, all of otolith sections at constant magnification, are annotated with marks to indicate the position of each annulus. Table 1 includes comments on the structures seen in the photographs. The following types of abbreviations occur in the Table:

S_2 = second hyaline ring split

C_2 = check in the second opaque zone

D_1 = diffuse first hyaline zone

W_2 = wide second hyaline zone

Specimen numbers prefaced by K or J were collected in November and December 1975. Specimen numbers prefaced by the Division designation were collected as follows:

2J - February 1975
3K - April 1976
3L - June 1976

The first 18 specimens, collected in the fall of 1975 would each have been aged one year older on January 1, 1976.

References

ICNAF. MS 1977. Preliminary report of Ageing Workshop on Cod held at St. John's, Canada, 31 January-5 February 1977 (R. Wells, convener). ICNAF Sum. Doc. 77/VI/12, Serial No. 5048.

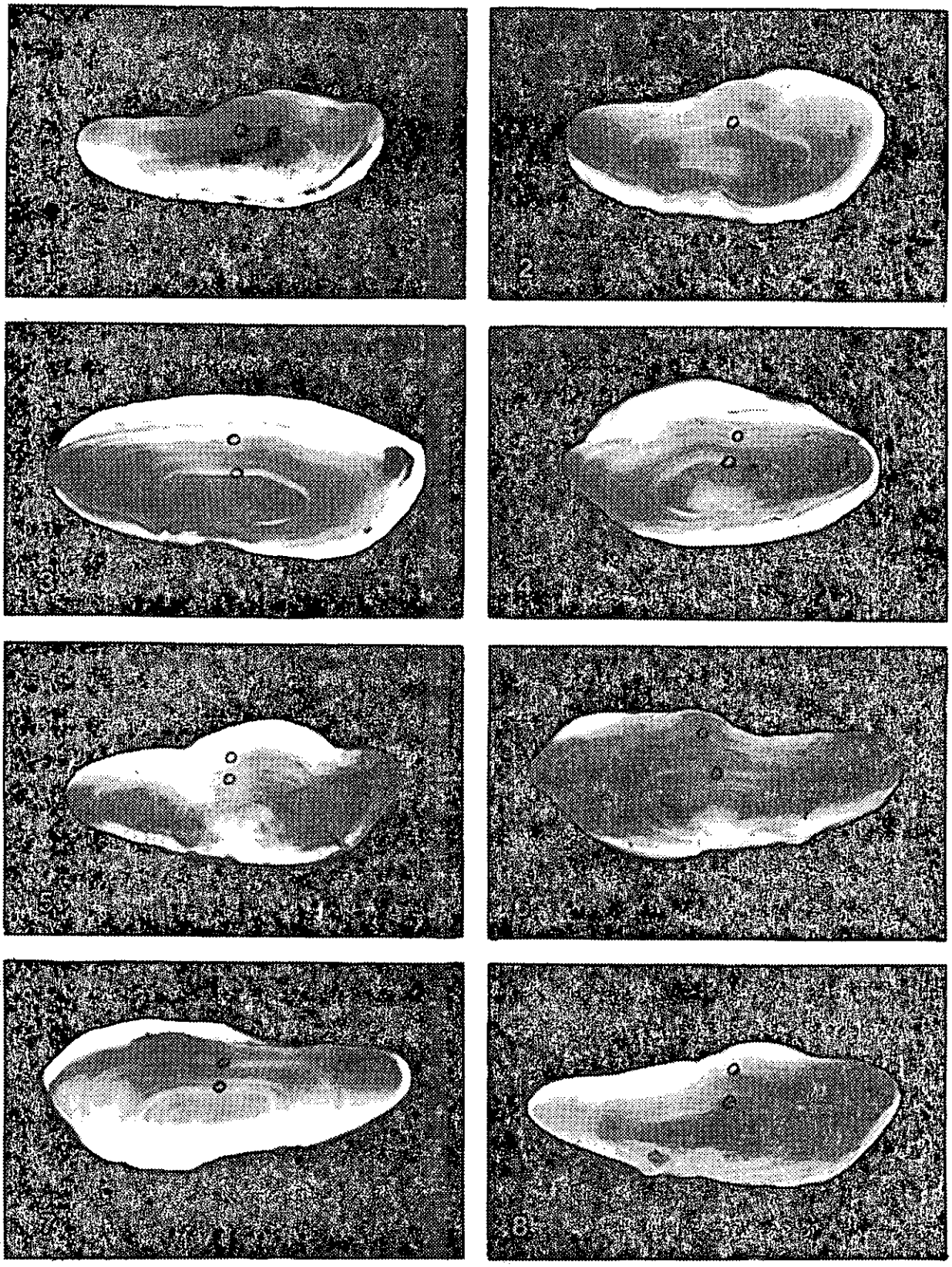
LOPEZ-VEIGA, E. G., R. WELLS, and V. M. HODDER (Ed.). 1977. Report of Ageing Workshop on Cod held at Vigo, Spain, October 1975.

Table 1. Ages and comments from the photographs of otoliths illustrated in the Appendix.

Photo. no.	Spec. no.	Fish length (cm)	Fish age (yr)	Edge of otolith	Comments
1	K-1	17	1	H	S_2
2	K-4	20	1	H	C_2
3	K-6	20	2	H	C_2
4	K-7	20	2	H	S_2
5	K-9	21	2	H	D_1
6	K-17	24	2	H	C_1
7	J-5	24	2	H	S_1
8	K-18	25	2	H	-
9	K-19	25	2	H	S_1
10	J-7	25	2	H	C_1, S_2
11	J-8	25	2	H	C_1, S_1
12	J-9	26	2	H	C_2
13	J-10	26	2	H	-
14	J-14	27	2	H	S_1
15	K-23	28	2	H	C_1, S
16	J-20	30	2	H	-
17	K-25	31	2	H	S_3
18	J-22	31	3	H	W_2
19	3L-1	31	3	H	-
20	3K-1	37	3	H	S_1
21	3K-2	40	3	H	W_1, S_2
22	3L-8	40	3	H	-
23	3L-12	40	3	H	S_1, S_2
24	2J-1	34	4	H	C_2, S_2, S_4
25	2J-2	37	4	H	D_2, S_3
26	2J-3	40	4	H	S_3
27	3L-11	40	4	H	-
28	3K-3	43	4	H	S_2, S_3
29	3K-4	43	4	O	S_3, S_4
30	3L-16	43	4	H	S_3
31	3L-17	43	4	H	D_1, C_3
32	3L-24	43	4	H	S_1, C_2
33	3K-6	46	4	H	S_2, S_3, S_4
34	3K-9	46	4	H	S_2, cut off center
35	3L-29	46	4	O	S_1, W_2, S_3
36	3K-10	49	4	H	C_3, S_4
37	3K-14	49	4	H	C_1, S_3
38	3L-40	49	4	H	S_3
39	3L-42	49	4	H	C_2, S_2, S_4
40	3L-50	52	4	O	S_1, S_3, S_4
41	3K-38	55	4	O	C_1, S_2
42	2J-5	43	5	H	C_4
43	2J-6	45	5	H	C_1, C_2, S_3
44	2J-8	46	5	H	S_2, S_3
45	2J-9	47	5	H	S_3, C_4
46	3K-12	49	5	H	S_2, C_5, S_5
47	3K-15	49	5	H	S_2, C_5
48	3K-16	49	5	H	S_3, S_5
49	2J-23	50	5	H	C_2, C_3
50	3K-28	52	5	H	S_4, S_5
51	3L-56	52	5	H	S_2, S_3, S_4
52	3K-32	55	5	O	S_2, S_4

Table 1. Continued

Photo no.	Spec. no.	Fish length (cm)	Fish age (yr)	Edge of otolith	Comments
53	3L-63	55	5	H	S_1, S_2, S_3, S_4, S_5
54	3L-66	55	5	H	C_3, S_4
55	3K-48	58	5	O	C_4, S_4, C_5
56	3L-68	58	5	O	C_1, S_2, S_3, S_4
57	3L-77	61	5	H	S_3, S_5
58	3L-83	64	5	H	S_2
59	2J-16	48	6	H	S_1, S_2
60	2J-30	51	6	H	W_2
61	2J-38	51	6	H	C_2, S_2, S_3
62	2J-25	52	6	H	C_2, S_2, S_3, C_4, S_6
63	3K-18	52	6	H	W_2, S_4, S_6
64	3K-30	52	6	H	W_2, S_2, S_3
65	2J-48	54	6	H	W_3, C_4
66	2J-49	54	6	H	C_2
67	3K-34	55	6	H	S_3
68	3K-41	55	6	H	S_2, S_4
69	3K-42	55	6	H	S_1, C_4
70	3K-65	61	6	H	S_2, S_4
71	3L-85	67	6	H	S_2, S_3
72	3L-97	73	6	H	C_4, C_5
73	3L-98	76	6	O	S_1, C_2
74	2J-12	48	7	H	S_3, S_4, S_5
75	2J-20	49	7	H	C_4, S_5, S_6
76	2J-34	52	7	H	S_2, S_5
77	2J-37	52	7	H	S_2, C_6
78	2J-39	52	7	H	C_2, C_3
79	2J-45	55	7	H	C_2, S_2, C_4, S_5
80	3K-35	55	7	H	S_1, C_3, C_4, S_5
81	3K-36	55	7	H	S_3, S_6
82	3K-39	55	7	H	C_2
83	3L-81	64	7	H	S_4, S_6
84	3L-94	73	7	H	S_4, S_5, S_6
85	2J-18	49	8	H	C_2, C_7
86	3K-43	55	8	H	C_2, S_3, S_4, S_5
87	2J-47	56	8	H	C_2, S_3, S_5, S_6
88	3L-90	70	8	H	S_3, S_7
89	3L-91	70	8	H	S_2, S_4, S_6, S_7
90	3L-95	73	8	H	C_2, C_4, C_5, S_7, S_8
91	3L-100	76	8	H	S_1, S_2, S_3
92	2J-27	53	9	H	W_1, S_2, S_3
93	3K-44	55	9	H	S_4
94	3K-45	55	9	H	S_3, S_4, S_5, S_6
95	3K-49	58	9	H	C_2, C_5, C_8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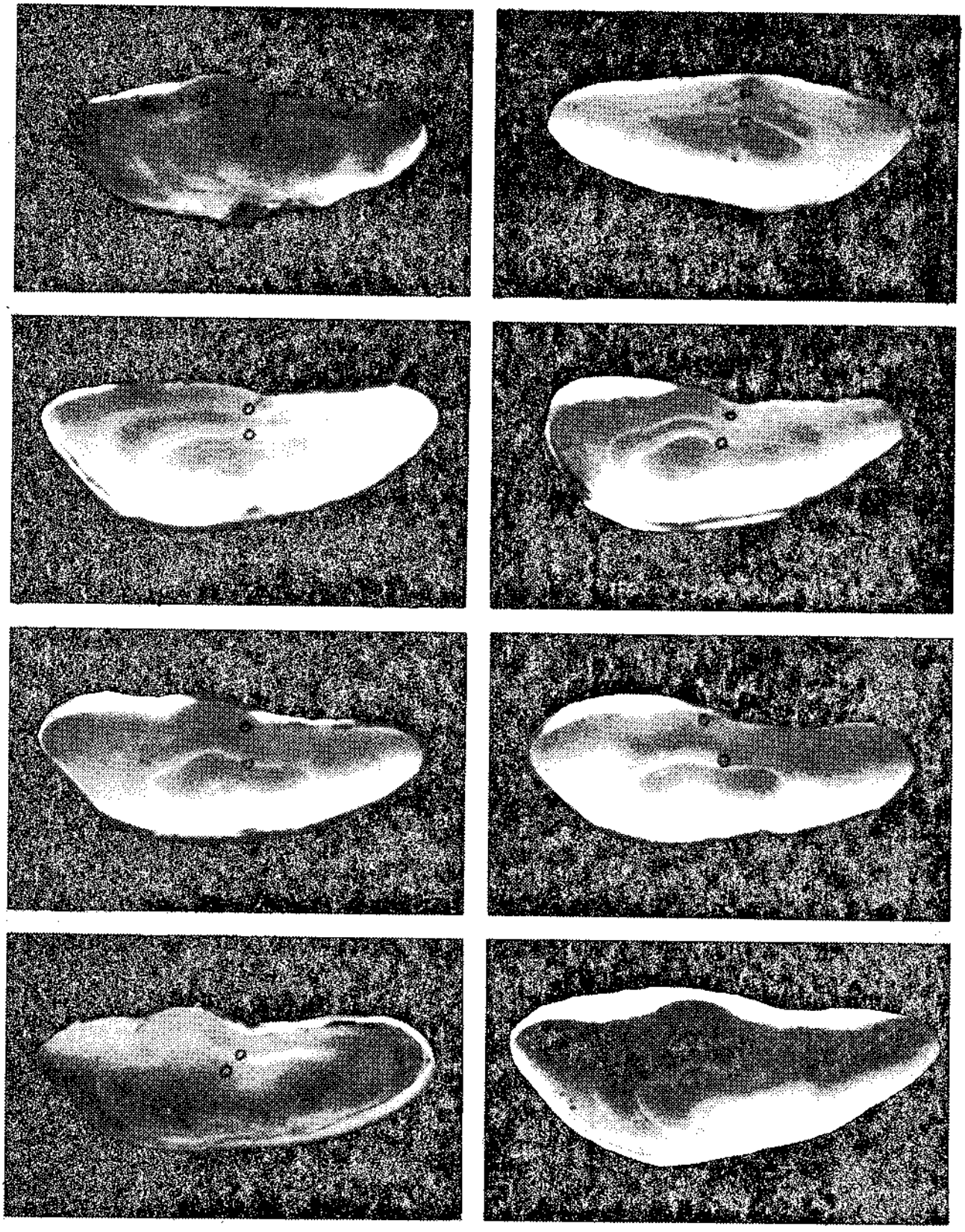

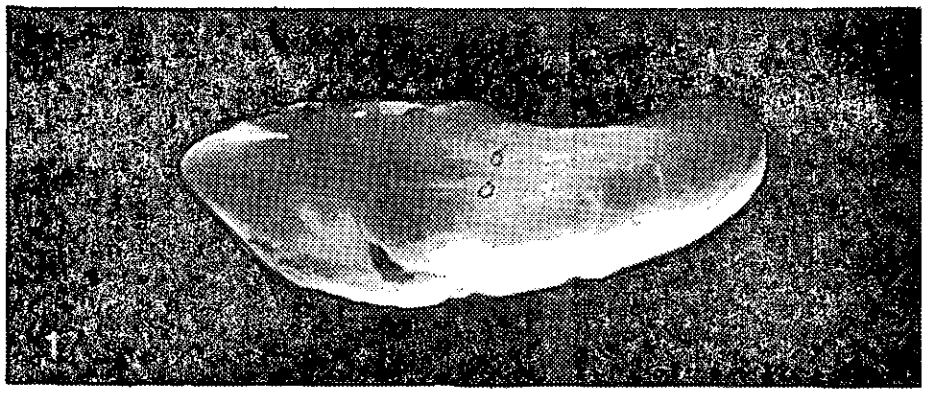

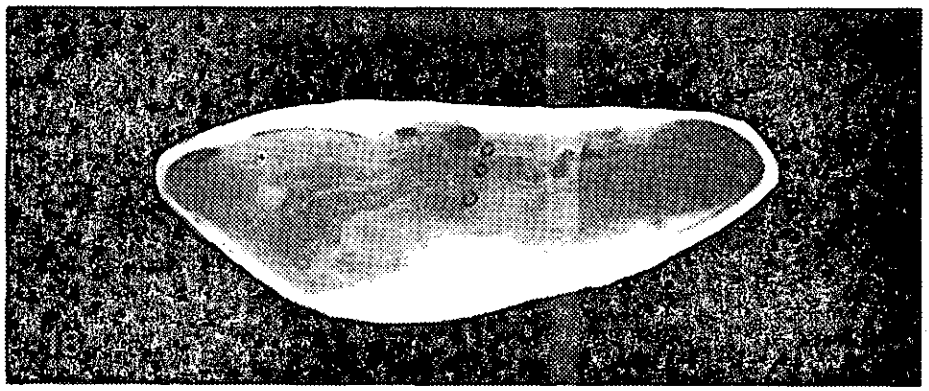

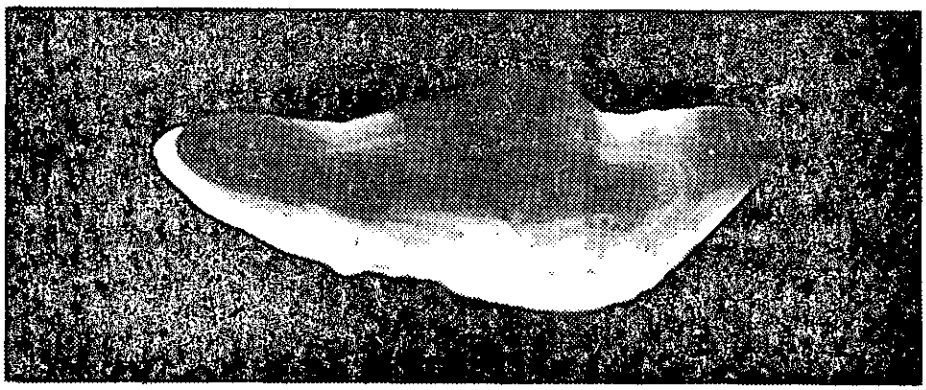

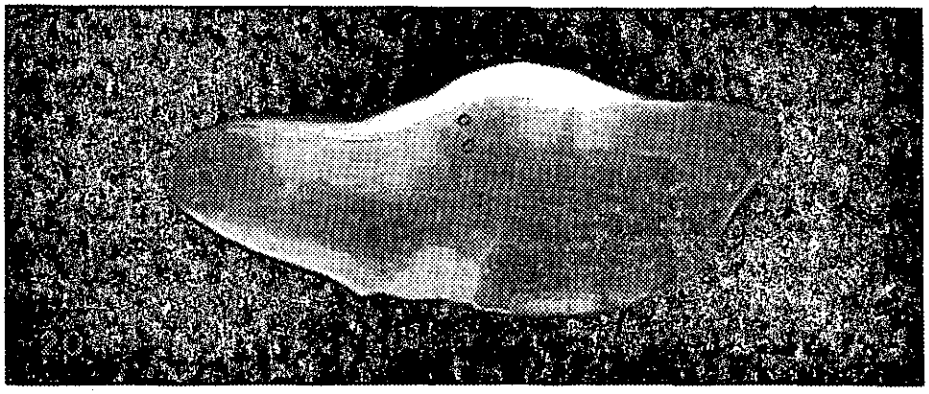

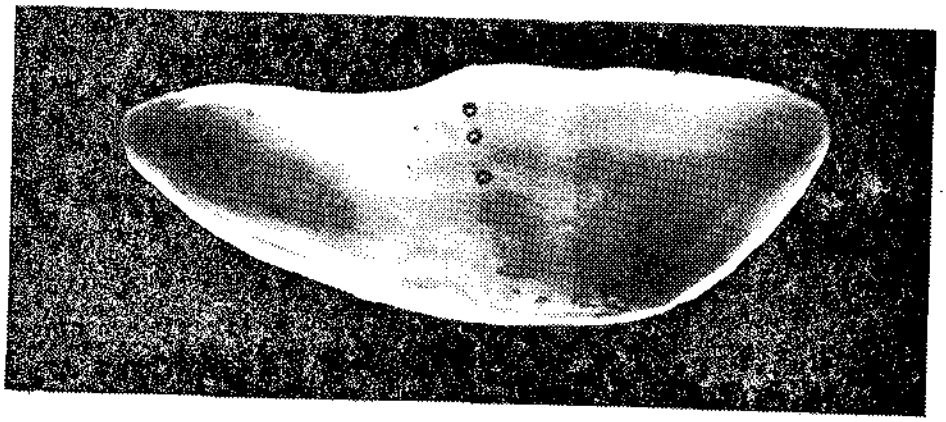

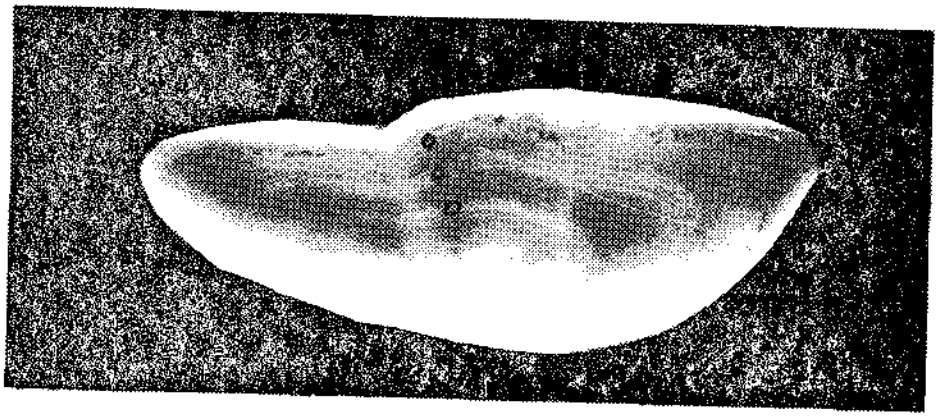

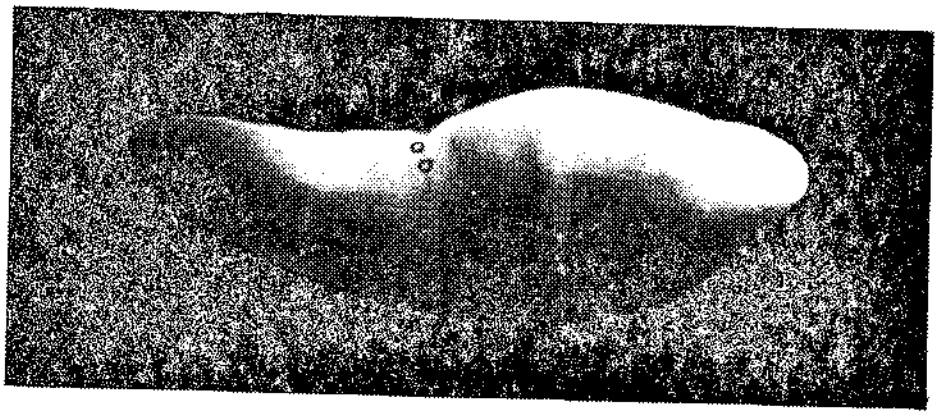

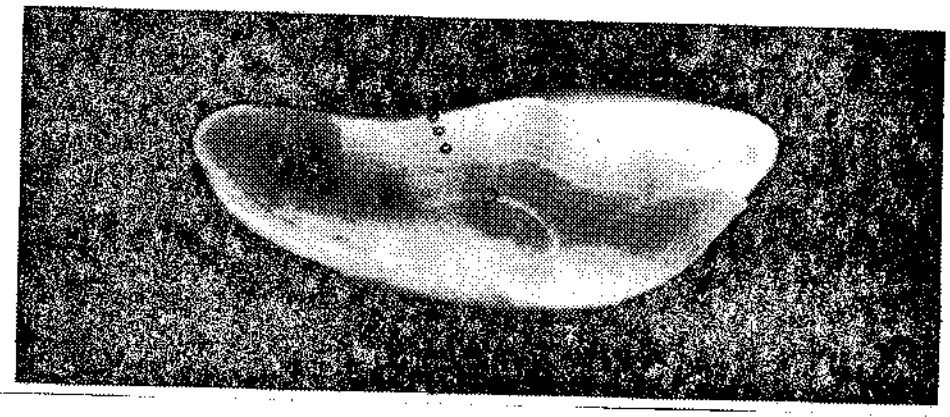

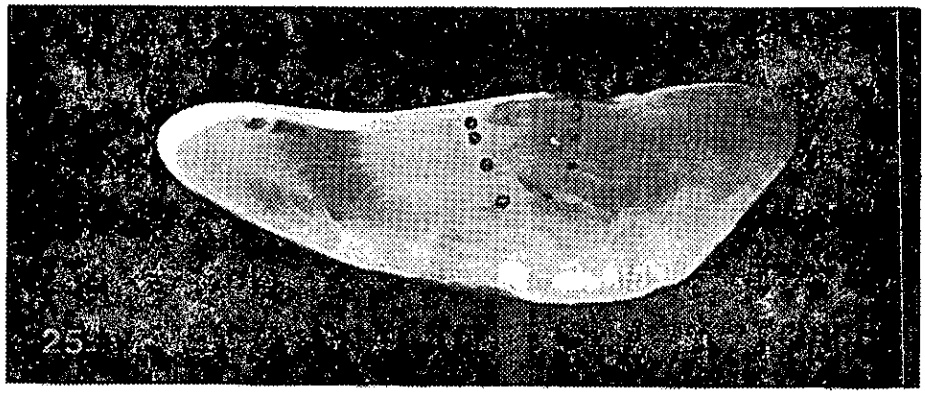

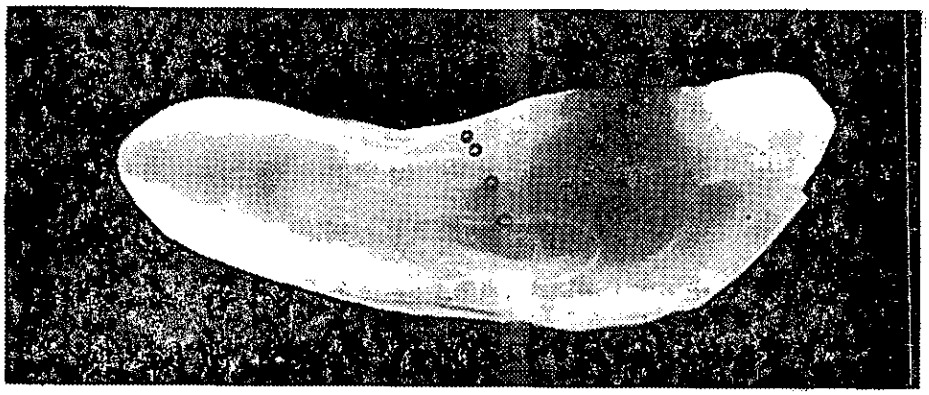

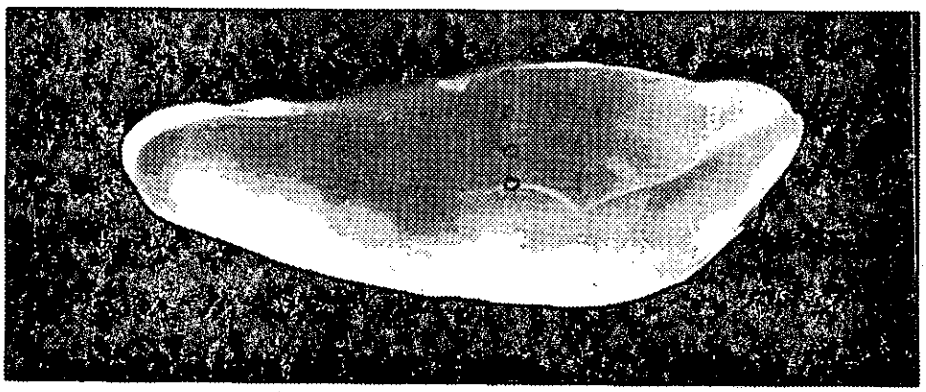

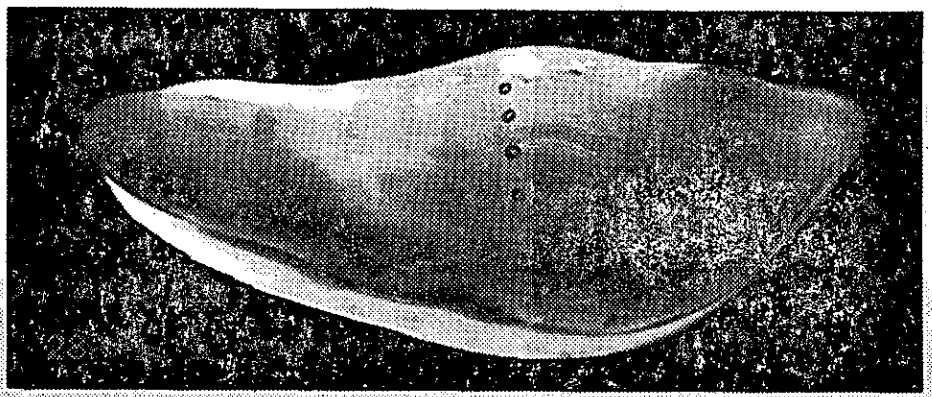

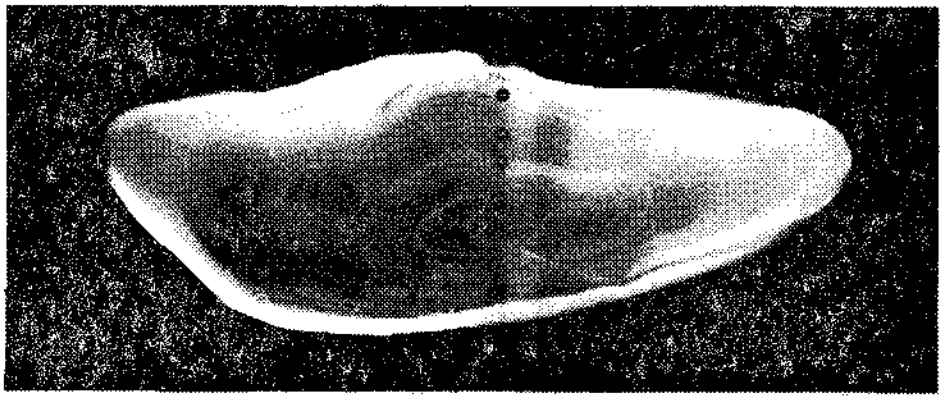

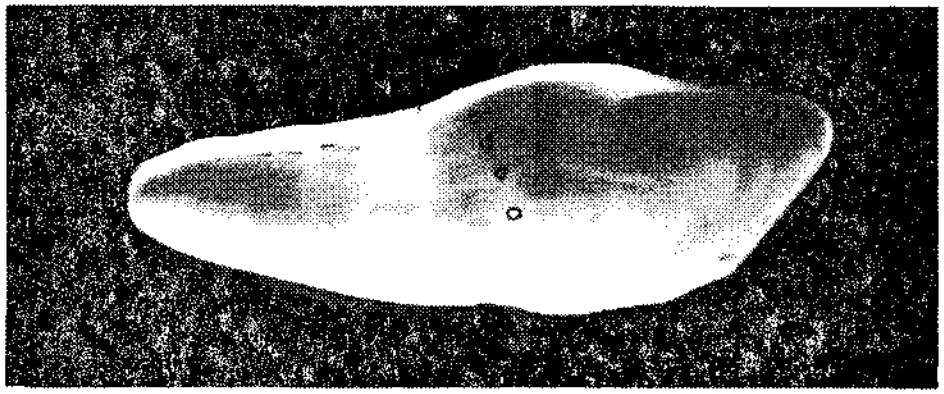

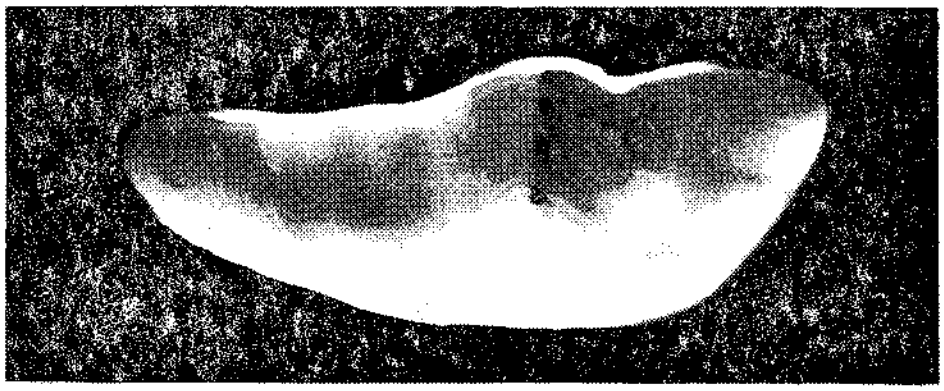

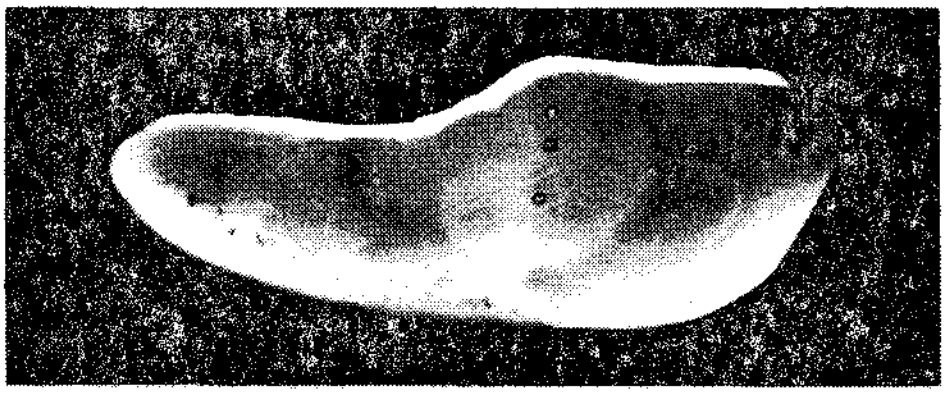

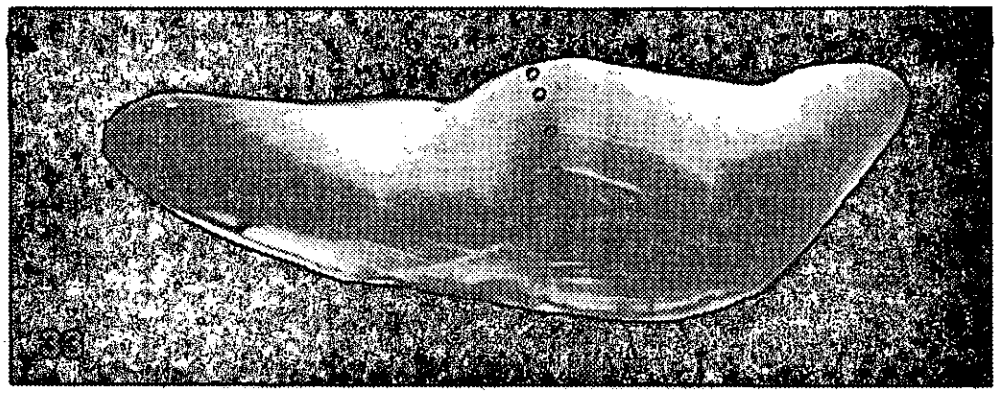

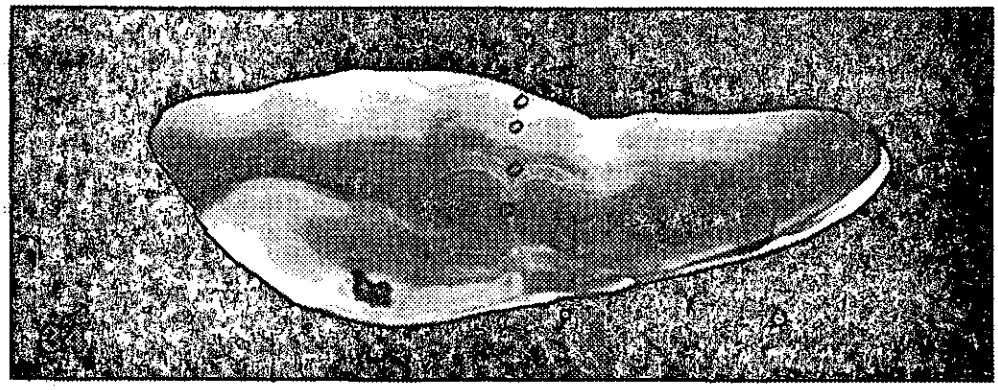

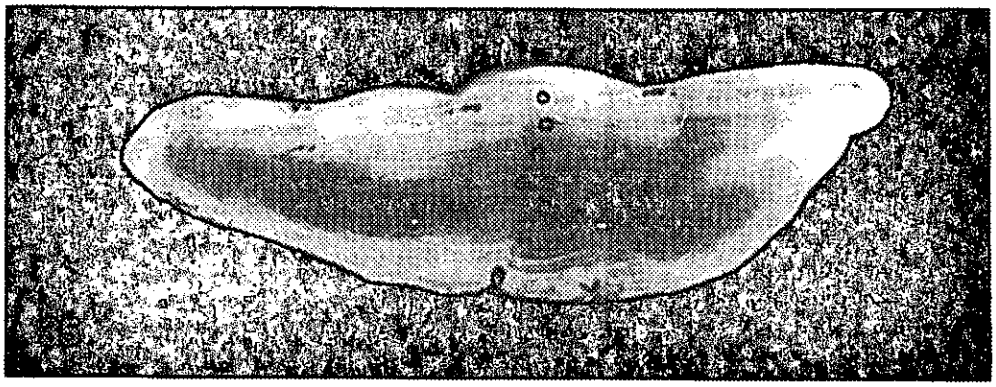

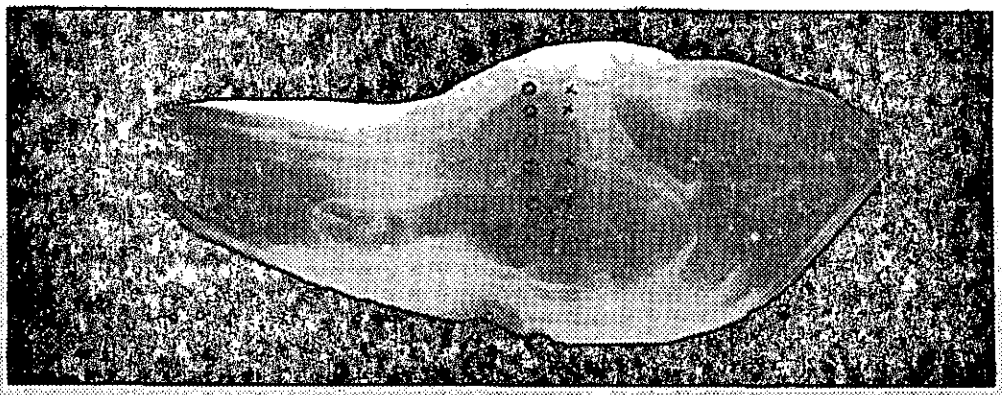

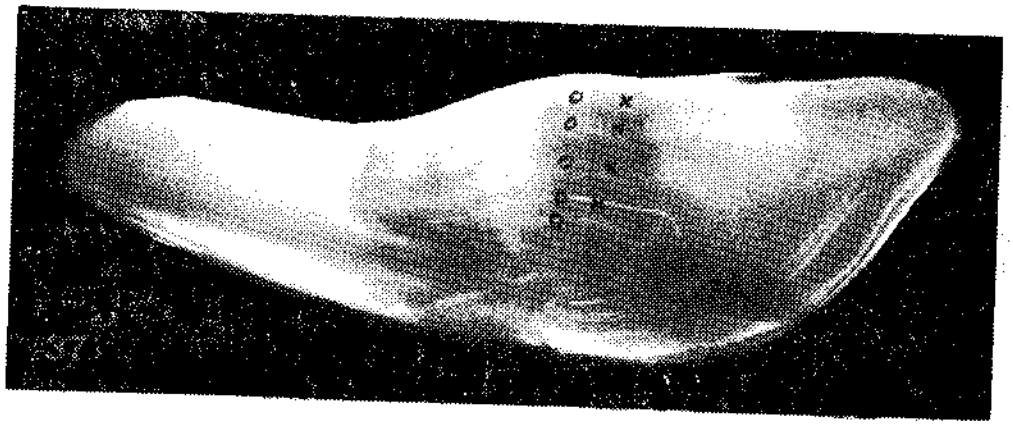

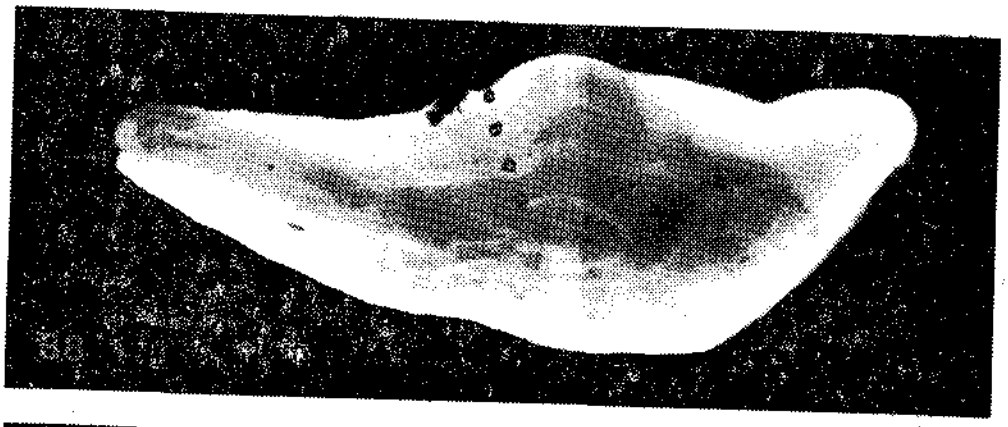

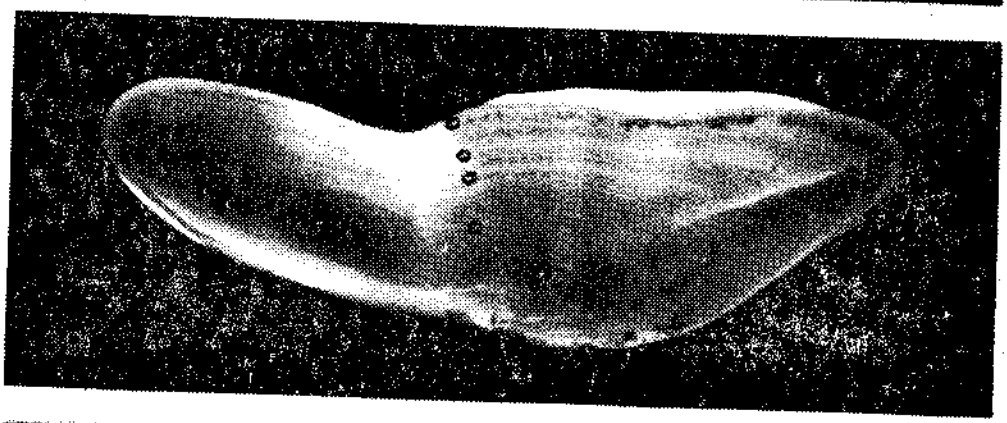

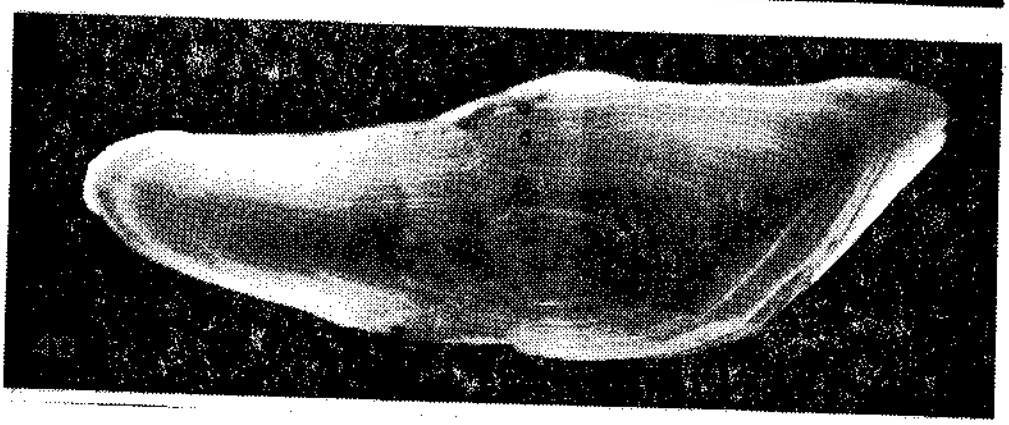

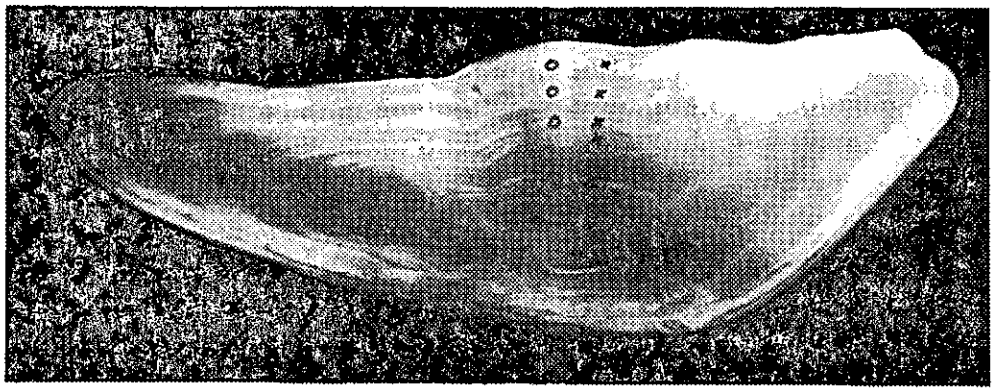

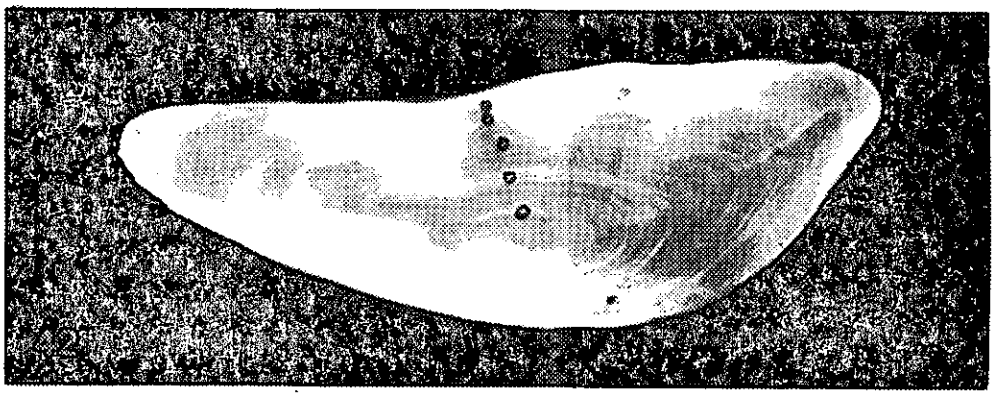

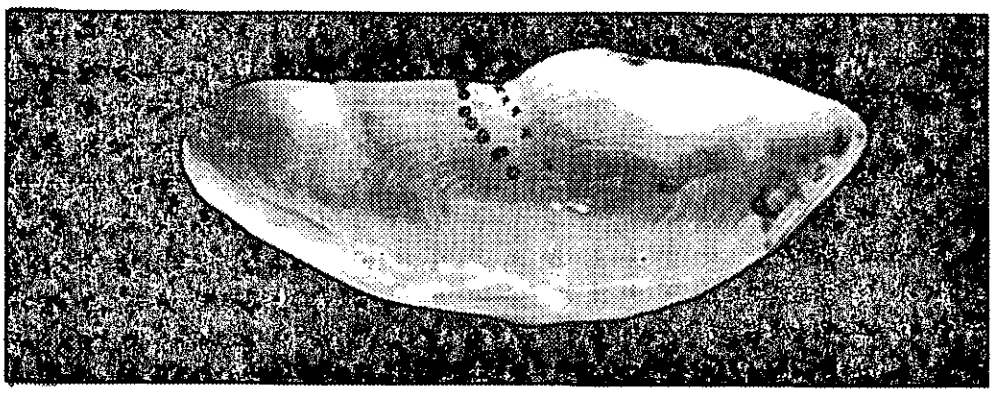

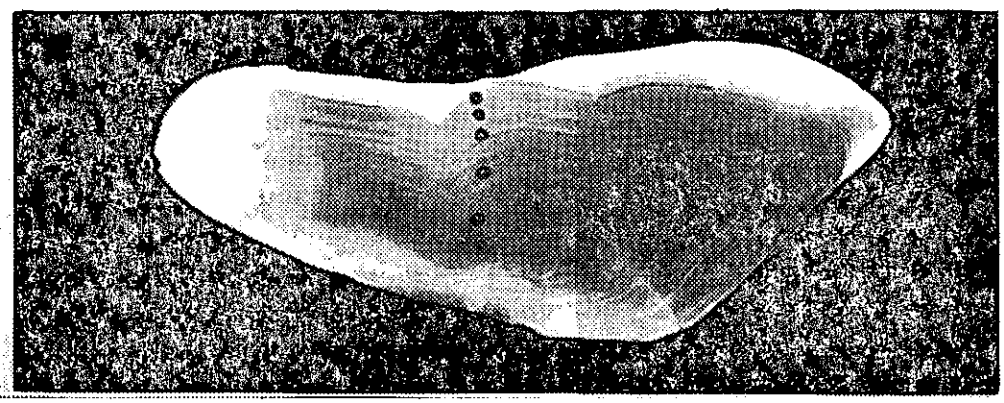

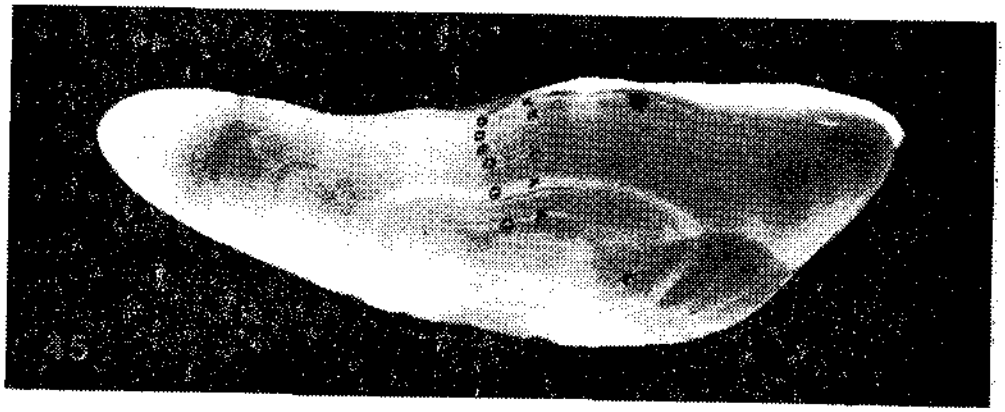

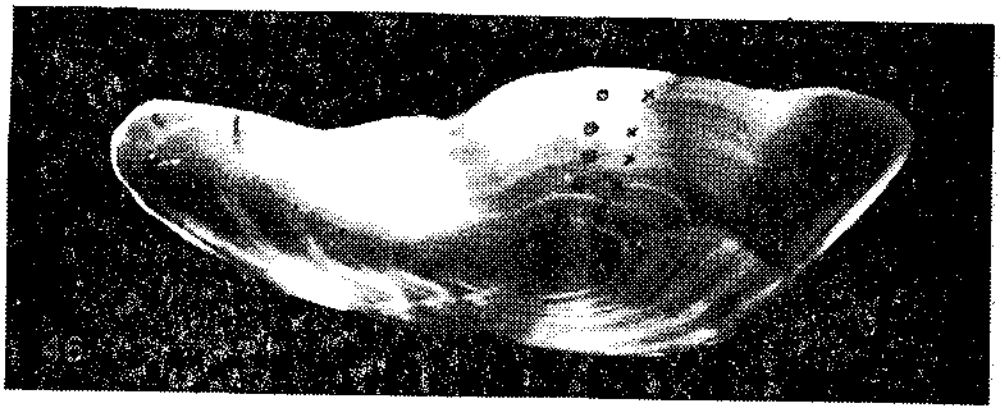

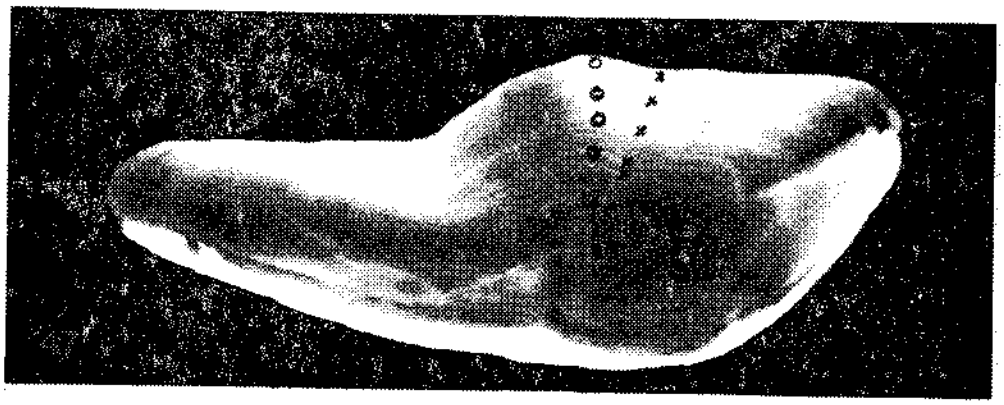

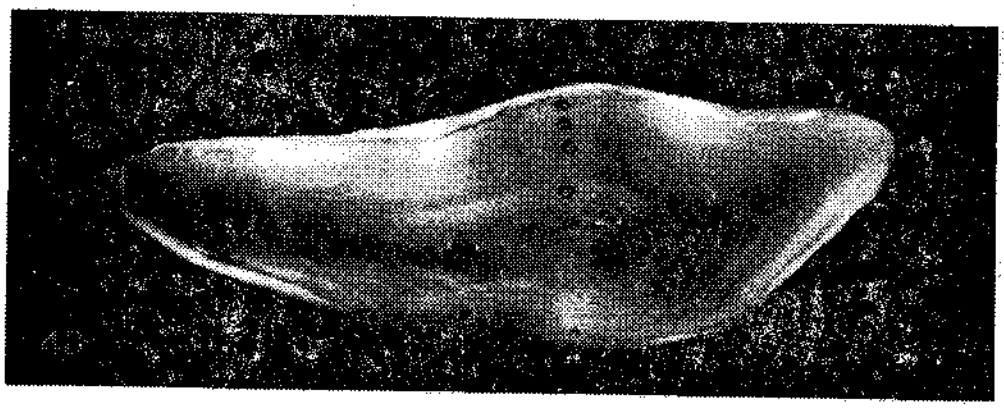

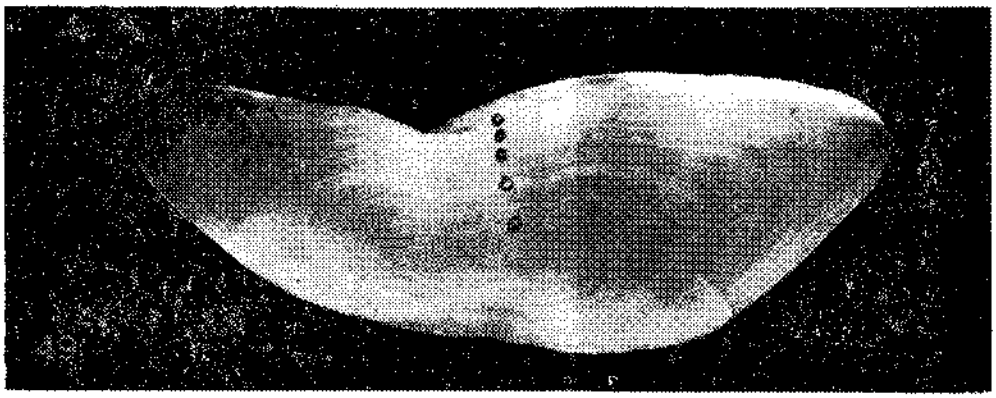

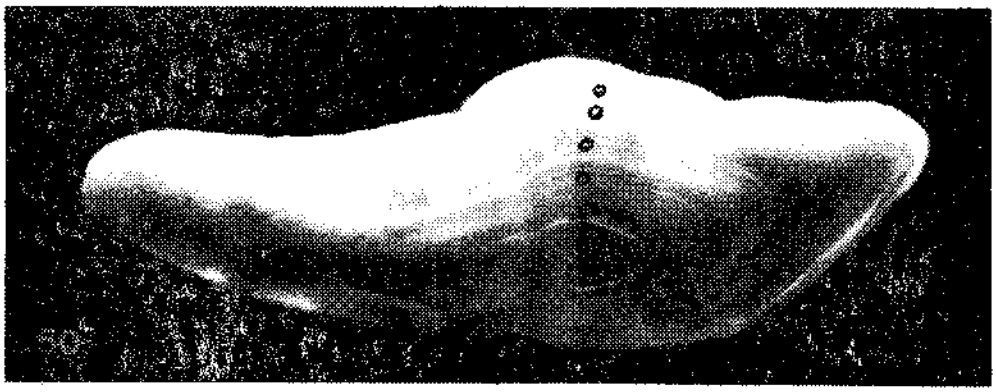

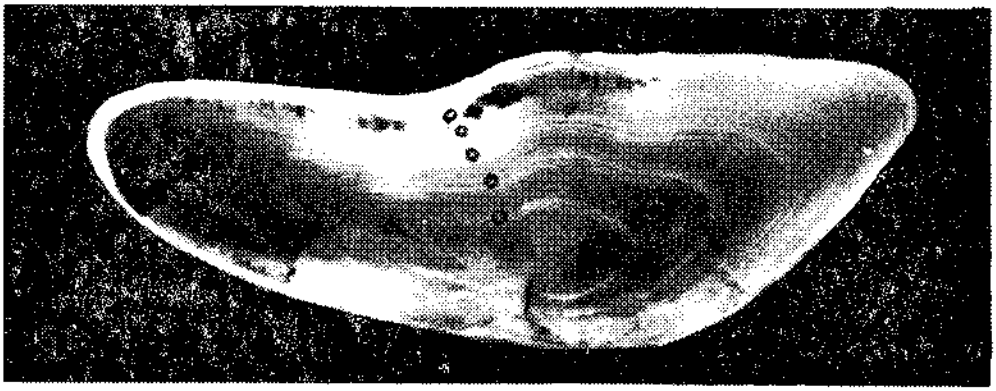

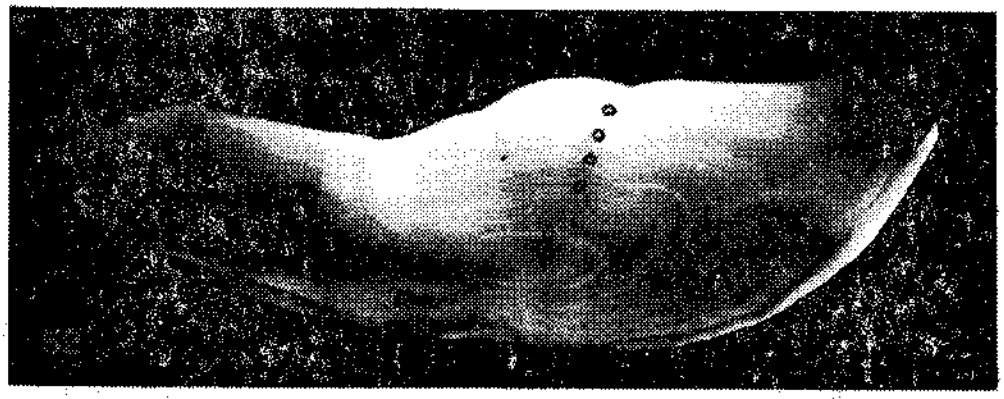

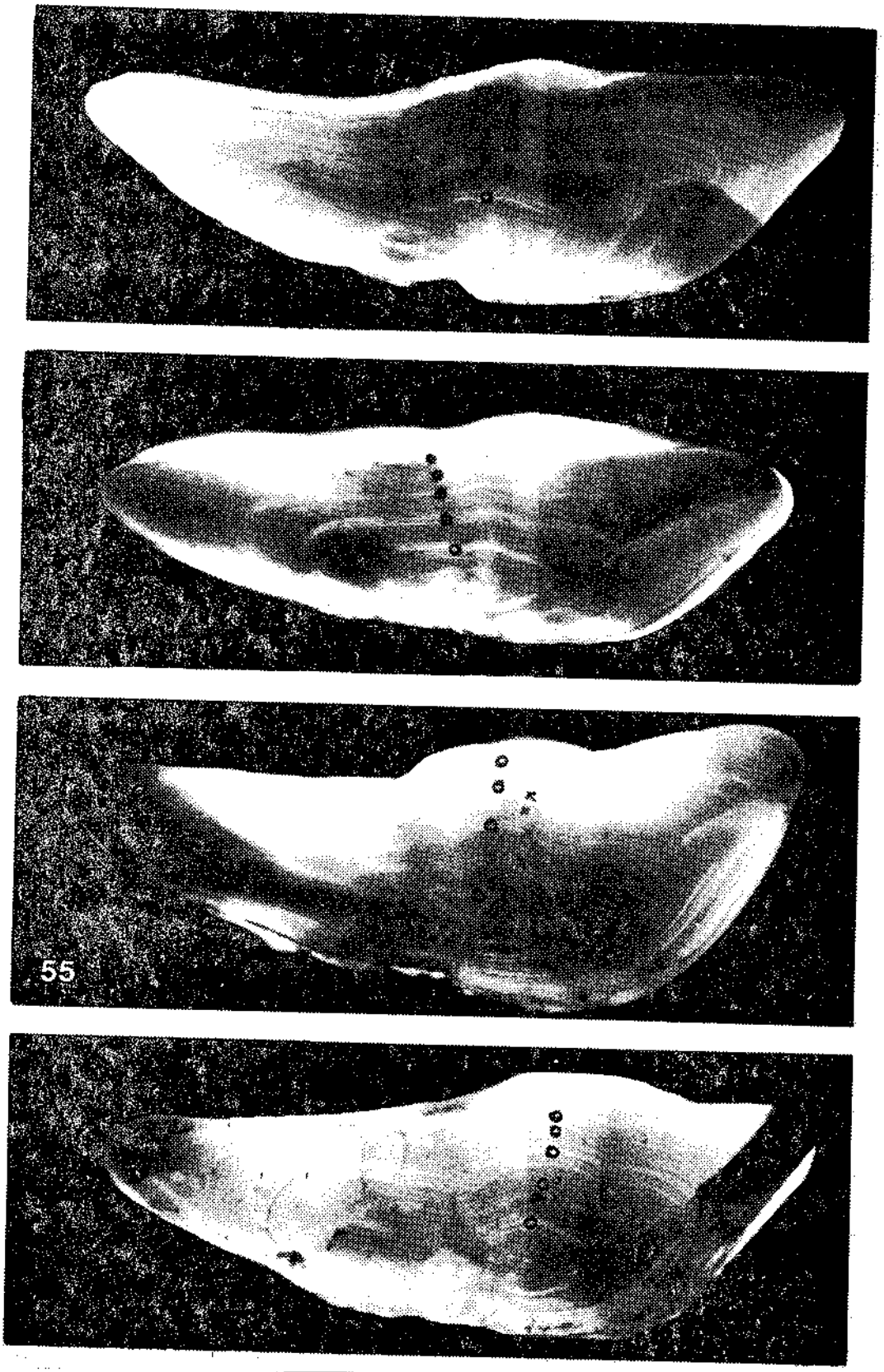
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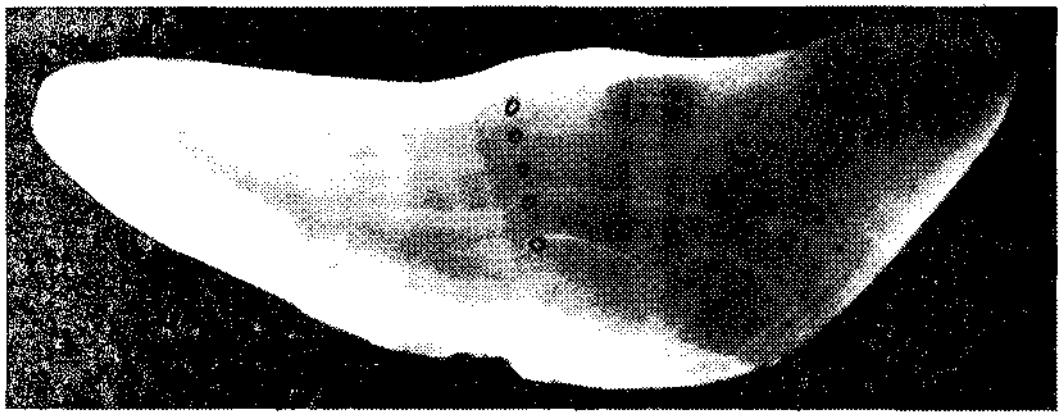

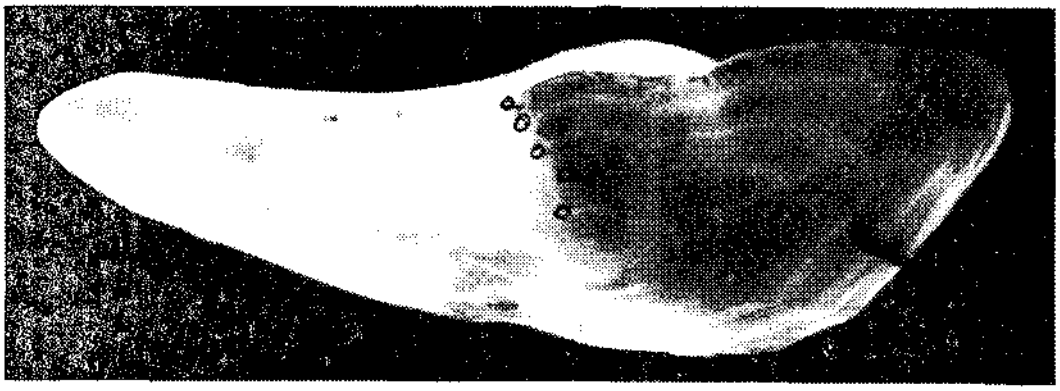

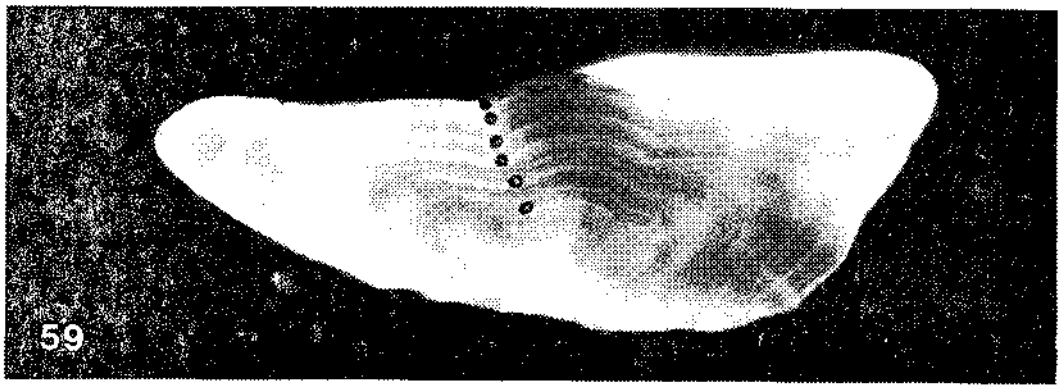

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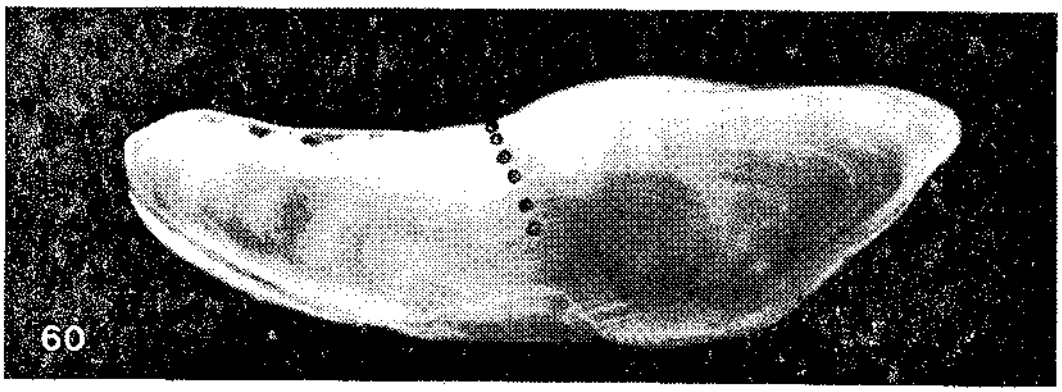

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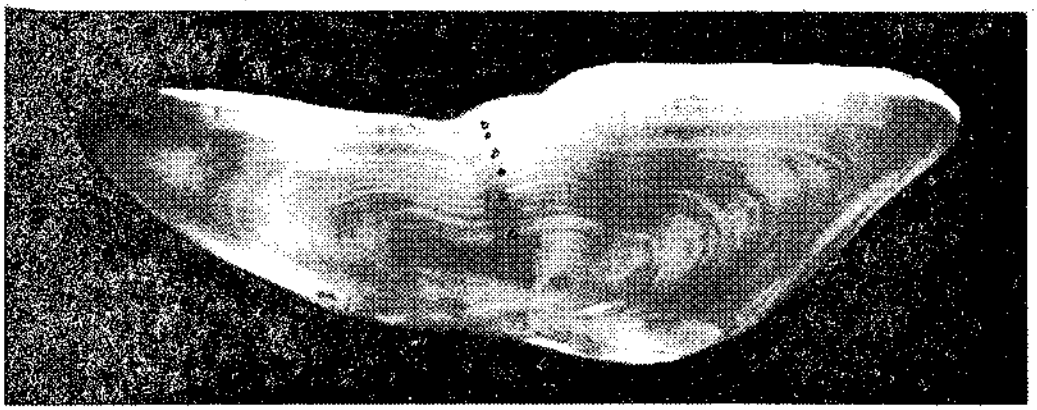

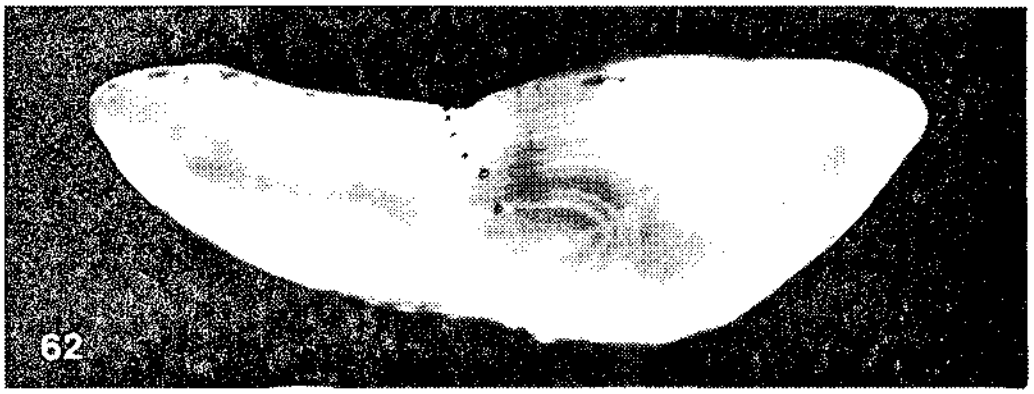
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