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Paleocene Pycnodont fishes from Jabal Umm Himar, Harrat Hadan area, Kingdom of Saudi Arabia

by

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PALEOCENE PYCNODONT FISHES FROM JABAL UMM HIMAR, HARRAT HADAN AREA, KINGDOM OF SAUDI ARABIA

by

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ABSTRACT

Three species of Pycnodus, a genus of extinct holostean fishes, have been identified from the Paleocene of Jabal Umm Himar, Harrat Hadan area, south-central Saudi Arabia, an area that was contiguous with Africa during the Early Tertiary. One of the species is larger than any species identified from the Early Tertiary of Africa. Its lower teeth are from 60 to 100 percent wider and 50 percent longer than those in P. mokattamensis, hitherto the largest species known from Africa. The second species, the most poorly represented of the three, is in dental size roughly 40 percent as large as the first species or about the same size as P. variabilis of Africa. The third species is small and, although the position of its teeth cannot be determined, this species clearly is distinct from the two other pycnodonts from Jabal Umm Himar.

INTRODUCTION

Pycnodontiformes, often called pycnodonts, are an extinct order of holostean fishes. These fishes had deep, nearly circular bodies, body armor of jointed rodlike scales, and mouths containing many pebblelike, irregularly arranged crushing teeth. Although it has been commonly thought that the pebblelike teeth were adapted for crushing corals (Romer, 1966), it seems more likely that they were adapted for crushing thin-shelled animals (Slaughter and Thurmond, 1974). Pycnodontiformes are known from the Mesozoic of Europe, Asia, Madagascar, Africa, South America, and North America. However, they survived into the Early Tertiary only in Europe, Asia, and Africa.

In 1974, D. L. Schmidt of the U.S. Geological Survey (USGS) collected the first pycnodont from Jabal Umm Himar Harrat Hadan area, At Taif region, Kingdom of Saudi Arabia (fig. 1). The vertebrate and invertebrate fauna from that general locality, the Umm Himar local fauna, is of Paleocene age (Madden and others, 1979/1980). During 1978 and 1979,

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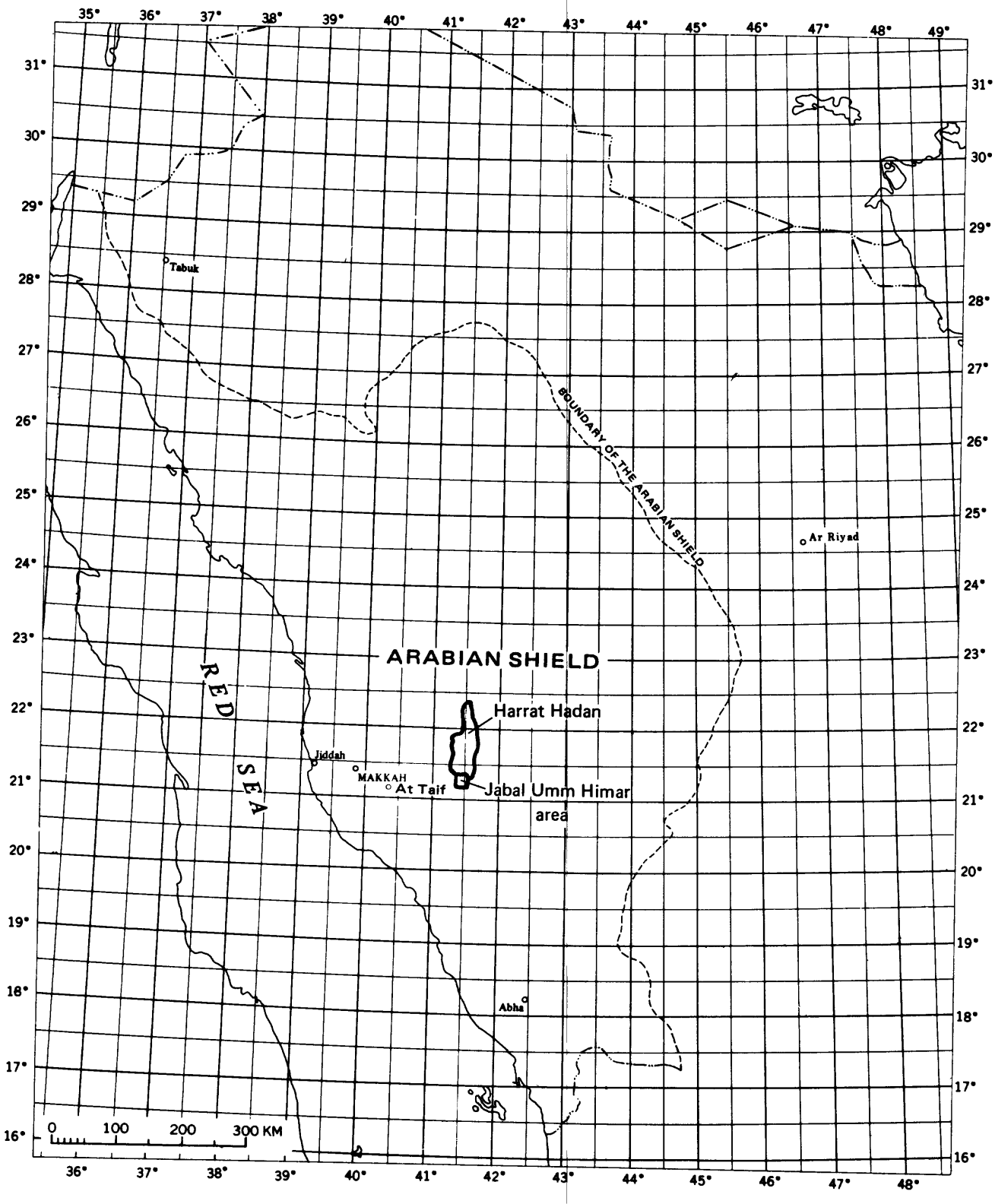

Figure 1.--Index map of western Saudi Arabia showing location of the Jabal Umm Himar area.

11 additional Paleocene pycnodonts were collected from localities at Umm Himar. Because Arabia was contiguous with Africa until the latest Oligocene (Brown, 1970), the Umm Himar pycnodonts must be compared to those of the Early Tertiary of Africa. Romer (1966) stated that Palaeobalistum de Blainville, 1818, and Pycnodus Agassiz, 1833-1843, are the only genera of pycnodonts known from the Paleogene of that continent. Despite priority, Agassiz (1833-1843) synonymized de Blainville's Palaeobalistum with his Pycnodus. However, the two genera can be clearly distinguished by their dentition. Crushing teeth in the former genus are oval, circular, and hemispherical (de Blainville, 1818; Heckel, 1856; Arambourg, 1954), whereas those in the latter are usually elliptical (Agassiz, 1833-1844; this report). On the basis of tooth morphology it is concluded that Pycnodus is the only genus of pycnodonts known from the Early Tertiary of Africa. It ranges from early to late Paleocene (Danian to Thanetian) in West Africa and from early to middle Eocene (Ypresian to Lutetian) in North Africa. All 12 specimens from Umm Himar appear to represent Pycnodus. These specimens are the first pycnodonts known from the Paleocene of Arabian-North African region.

Previous investigations

The geology of the Jabal Umm Himar area was described by Baghanem (1972) in a master's thesis for the South Dakota School of Mines and Technology. In 1970, Baghanem, then a geologist with the Saudi Arabian Directorate General of Mineral Resources, collected the first fossils, including turtle remains (Order Chelonia), from the Umm Himar area.

In 1971, two fossil vertebrae were collected by Schmidt from locality 1 (fig. 2). These were identified in 1974 by F. C. Whitmore, Jr., USGS, as representing a large member of the Mesosuchia, a widely distributed (Africa, Europe, Asia, North America, and South America) suborder of primitive crocodilians that originated in the Early Jurassic and became extinct in the Middle Eocene.

Madden and others(1979/1980) recorded the Paleocene vertebrates, stratigraphy, and environment of deposition of rocks in the Jabal Umm Himar area. Their report, based on paleontologic and geologic field investigations undertaken in 1976, recorded the first Paleocene vertebrate fauna known from the Arabian Peninsula.

Acknowledgments

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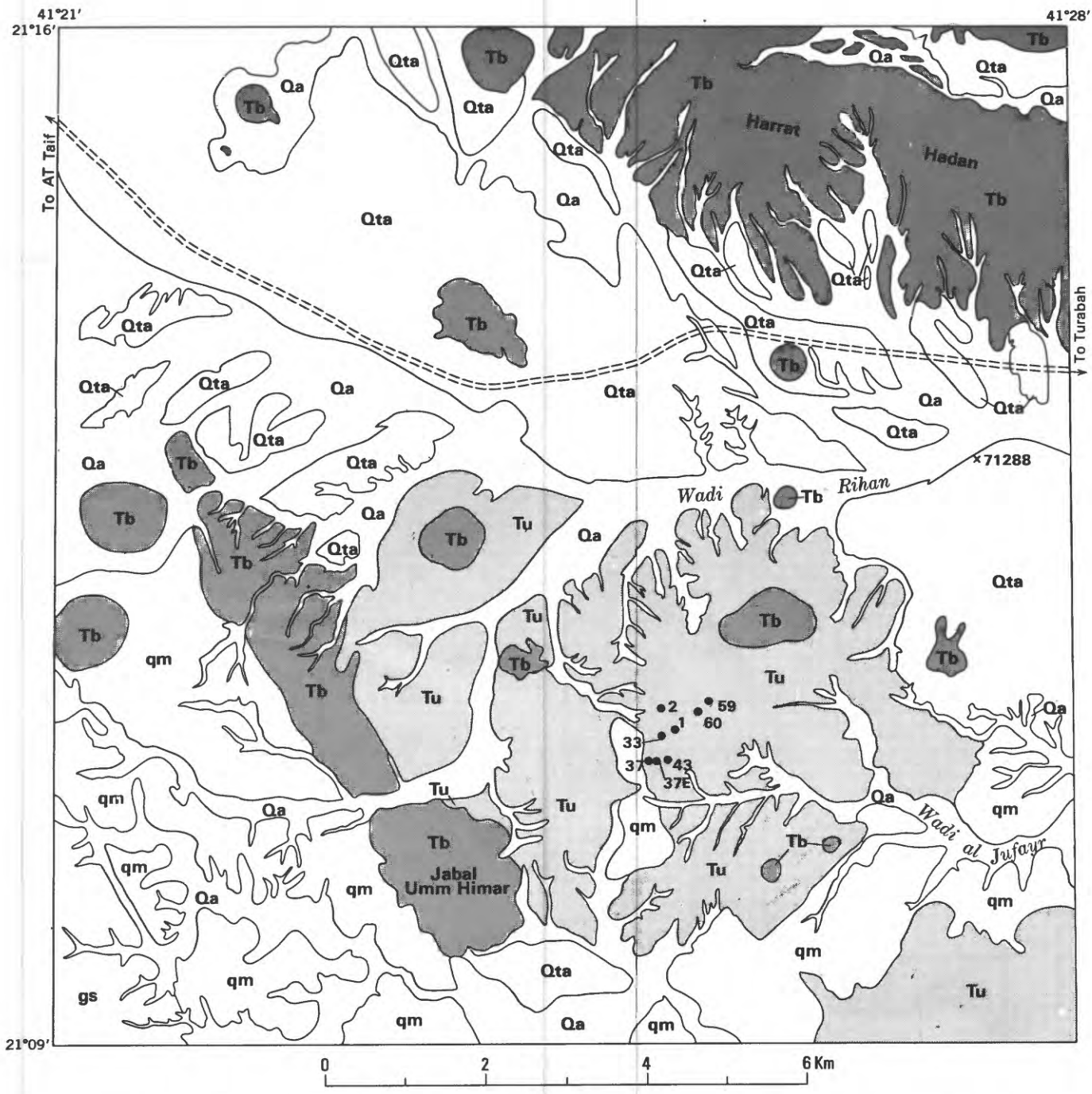

Figure 2.--Geologic map of the Jabal Umm Himar area showing fossil localities (adapted from Madden and others, (1979/1980). Explanation: •, fossil locality; Qa, Holocene alluvium; Qta, Pleistocene terrace alluvium; Tb, Miocene basalt; Tu, Paleocene Umm Himar formation (mudstone, shale, limestone); qm and gs, Precambrian rocks.

Jr., for reading the manuscript; and R. H. McKinney for photographing the specimens. The work on which this report is based was performed in accordance with a work agreement between the U. S. Geological Survey and the Saudi Arabian Ministry of Petroleum and Mineral Resources as part of a general geological study of the Tertiary rocks of western Arabia.

METHODOLOGY AND MATERIALS

All characters or variables stated in this report are continuous, were measured in millimeters (mm) three or more times with calipers calibrated to 0.01 mm, and are maximum values. The variables measured are 1) length and width of each crushing tooth from the inner, middle, or outer dental rows of the splenial or lower jaw and vomerine or upper jaw and 2) length, width, and height of "incisor" teeth in front of the crushing teeth. Length is the greatest anteroposterior diameter of each tooth, whereas width is the greatest mediolateral diameter. Relative width is the latter character divided by the former and multiplied by 100. The sample statistics used are defined and discussed in Simpson and others (1960). The following abbreviations are used: CL, ninety-five percent confidence interval; CV, coefficient of variation; L, length; W, width; N, number of samples; p, probability; $\bar{X}$, mean of samples observed; s, standard deviation of population; $s_{\bar{X}}$, standard deviation of mean of samples observed; t, statistic computed in student's or matched t statistical tests; z, statistic computed in z score statistical test (see Weinberg and Schumaker, 1974); alpha, type I error.

Length, width, and relative width of crushing teeth in North African and West African early Paleocene to middle Eocene Pycnodus variabilis Stromer, 1905, and North African early and middle Eocene P. mokattamensis Priem, 1897, are used as comparative standards in order to determine the possible tooth-row position and taxonomic identity of each crushing tooth from Jabal Umm Himar. Individual observations and sample statistics for teeth in the two species are given in tables 1-5.

The following are synonyms of Pycnodus variabilis: P. vasseuri Savorin, 1915 (p. 376, fig. 5), from the Eocene of Tocqueville, Algeria; P. tattami White, 1934 (p. 42, figs. 10-11), from the Paleocene of Wurno, Nigeria; and P. praecursor Dartevelle and Casier, 1949 (p. 212; pl. 17, A, C), from the Paleocene of Landana, Zaire (formerly The Congo). Crushing teeth in the splenial jaws on which the first and third "species" are based cannot be distinguished on the basis of size from those in Stromer's species (see lengths and widths from Savorin, Dartevelle and Casier, and

Van Neer in table 1); the same may be said for the teeth in two vomerine jaws on which the second "species" was based (see lengths and widths from White in table 2).

The following are synonyms of Pycnodus mokattamensis: P. pellei Priem, 1903 (p. 402, pl. 13, fig. 5), from the early Eocene of Gafsa, Tunisia, and the Eocene of Rilassa, Algeria (Savorin, 1915, p. 371, fig. 1) and Kouif, Algeria (Arambourg, 1952, p. 229, pl. 37, fig. 29); P. lemellefensis Savorin, 1915 (p. 371, fig. 2), from the Eocene of Bord-Redir, Algeria; and P. legrandi Savorin, 1915 (p. 374, fig. 3), P. thamallelensis Savorin, 1915 (p. 375, fig. 4), and P. cf. bowerbanki Egerton, 1877; Savorin, 1915 (p. 377), all from the Eocene of Tocqueville, Algeria. Crushing teeth in the vomerine and splenial jaws of all these "species" cannot be distinguished on the basis of size from those in P. mokattamensis (compare lengths and widths from Priem, 1903, and Savorin, 1915, with those from Priem, 1897 and 1899 in tables 2-3).

Pycnodus variabilis Stromer, 1905, is clearly distinct from P. mokattamensis Priem, 1897, for the following reasons.

1. In relative terms, the middle splenial crushing teeth in Stromer's species are significantly wider, the outer splenial teeth significantly narrower, and the vomerine crushing teeth significantly narrower than in Priem's species (tables 4-5).

2. Splenial and vomerine crushing teeth in the former species are about 40 percent and 57 percent smaller, respectively, than those in the latter species (tables 1-3). This difference is significant because student's t or matched t tests indicate that the probability (p) that length and width of crushing teeth in the first species are sampled from populations similar or identical to those known from the second is less than 25 chances in 1,000 ($p < 0.025$).

3. Pycnodus variabilis is the only Paleocene species known, and it is known only from the Paleocene of West Africa, whereas both P. variabilis and mokattamensis are known from the Eocene, though only from North Africa (table 6).

The only other pycnodont known from the Early Tertiary of Africa is a very small species described from the late Paleocene (Thanetian) of Nigeria by Cappetta (1972, p. 222, pl. 11, fig. 3-4) as "Pyncodus cf. praecursor Dartevelle et Casier, 1949." The crushing teeth in this unnamed species are relatively wider or more elliptical and considerably smaller than those in either P. mokattamensis or P.

Table 1.--Previously reported individual observations and sample statistics for length and width of splenial teeth in inner, middle, and outer rows of *Pycnodus variabilis*

[Leaders indicate no data available. Abbreviations defined in text]

Inner		Middle		Outer		Reference
L	W	L	W	L	W	
2.5	5.9	2.0	3.7	-	-	Stromer, 1905
2.8	5.3	1.8	3.5	2.0	2.0	Stromer, 1905
3.5	8.0	3.0	6.5	3.0	3.9	Stromer, 1905
4.2	10.1	4.0	6.6	3.5	4.0	Stromer, 1905
6.6	11.5	4.4	7.7	4.4	6.3	Stromer, 1905
9.0	18.5	6.7	9.5	6.1	8.5	Stromer, 1905
9.5	18.0	6.3	11.0	6.1	9.4	Stromer, 1905
5.6	10.9	4.8	9.0	4.2	6.0	Stromer, 1905
4.2	8.6	3.5	6.2	3.4	4.2	Stromer, 1910
10.1	26.6	8.4	14.7	-	-	Stromer, 1910
5.7	12.4	4.2	7.0	4.3	6.0	Savorin, 1915
3.1	7.3	2.1	5.3	-	-	White, 1934
6.2	11.2	4.2	7.3	-	-	White, 1934
4.5	9.1	3.6	6.9	3.1	4.9	Dartevelle and, Casier, 1949
5.8	12.7	-	-	-	-	Van Neer, 1979, written commun.
$\bar{X}$	5.6	11.7	4.2	7.5	4.0	5.5
$s_{\bar{X}}$	0.62	1.44	0.50	0.78	0.41	0.70
N	15	15	14	14	10	10
s	2.41	5.59	1.88	2.91	1.31	2.22
CV	43.0	47.8	44.8	38.8	32.7	40.4
CL	4.3-6.9	8.6-14.8	3.1-5.3	5.8-9.2	3.1-4.9	3.9-7.1

Table 2.--Previously reported individual observations and sample statistics for length and width of vomerine teeth in inner, middle, and outer rows of *Pycnodus variabilis* and *P. mokattamensis*

[Leaders indicate no data available. Abbreviations defined in text]

	Inner		Middle		Outer		Reference
	L	W	L	W	L	W	
				P. variabilis			
	3.0	4.4	3.0	3.0	3.1	1.9	Stromer, 1905
	5.0	7.0	4.0	5.3	4.5	2.7	Stromer, 1905
	2.7	4.1	2.5	3.5	3.3	2.1	White, 1934
	7.6	12.7	5.9	8.2	6.6	6.7	White, 1934
$\bar{X}$	4.6	7.0	3.8	5.0	4.4	3.3	
$s_{\bar{X}}$	1.13	1.99	0.75	1.17	0.8	1.13	
$\underline{N}$	4	4	4	4	4	4	
s	2.26	3.99	1.5	2.35	1.61	2.26	
CV	49.1	57.0	39.5	47.0	36.5	68.5	
CL	1.0-8.2	0.7-13.3	1.4-6.2	1.3-8.7	1.9-6.9	0.1-6.9	
				P. mokattemensis			
	10.0	14.5	12.0	9.0	11.0	8.0	Priem, 1897,1899
	10.0	18.0	12.0	8.0	8.0	-	Savorin, 1915
	10.0	16.5	12.0	8.0	11.0	8.0	Savorin, 1915
	9.0	15.0	10.0	8.5	-	-	Savorin, 1915
$\bar{\bar{X}}$	9.7	16.0	11.5	8.4	9.7	8.0	
$s_{\bar{\bar{X}}}$	0.25	0.79	0.5	0.24	0.88	-	
$\underline{N}$	4	4	4	4	4	4	
s	.5	1.58	1.0	.48	1.53	-	
CV	5.2	9.9	8.7	5.7	15.8	-	
CL	8.9-10.5	13.5-18.5	9.9-13.1	7.6-9.2	5.9-13.5	-	

Table 3.--Previously reported individual observations and sample statistics for length and width of splenial teeth in inner, middle, and outer rows of *Pycnodus mokattamensis*

[Leaders indicate no data available. Abbreviations defined in text]

	Inner		Middle		Outer		Reference
	L	W	L	W	L	W	
	10.0	20.0	8.5	11.5	7.0	13.0	Priem, 1897, 1899
	9.5	22.0	6.5	10.5	6.0	10.7	Priem, 1903
	12.0	22.0	-	-	-	-	Savorin, 1915
	8.1	16.2	5.6	8.7	5.6	8.3	Savorin, 1915
$\bar{X}$	9.9	20.0	6.9	10.2	6.2	10.7	
$s_{\bar{X}}$	0.8	1.36	0.86	0.82	0.42	1.36	
N	4	4	3	3	3	3	
s	1.61	2.73	1.48	1.42	.72	2.35	
CV	16.3	13.6	21.4	16.3	11.6	22.0	
CL	7.4-12.4	15.7-24.3	3.2-10.6	6.7-12.2	4.4-8.0	4.8-16.6	

Table 4.--Sample statistics for relative width of splenial teeth in inner, middle, and outer rows of Pycnodus variabilis and P. mokattamensis
[Calculated from data in tables 1, 3, respectively. Abbreviations defined in text]

	Inner	Middle	Outer
		P. variabilis	
$\bar{X}$	212.1	184.0	134.5
$s_{\bar{X}}$	6.5	6.95	5.66
N	15	14	10
s	25.16	25.98	17.87
CV	11.9	14.1	13.3
CL	198.2-226.0	169.0-199.0	121.70-147.3
		P. mokattamensis	
$\bar{X}$	203.7	150.7	170.7
$s_{\bar{X}}$	9.09	7.92	11.48
N	4	3	3
s	20.18	13.71	19.86
CV	9.9	9.1	11.6
CL	174.8-232.6	116.6-184.8	121.3-220.1

Table 5.--Sample statistics for relative width of vomerine teeth in inner, middle, and outer rows of Pycnodus variabilis and P. mokattamensis
[Calculated from data in table 2. Leaders indicate no data available. Abbreviations defined in text]

	Inner	Middle	Outer
		P. variabilis	
$\bar{X}$	151.4	127.9	71.6
$s_{\bar{X}}$	5.76	9.44	9.99
N	4	4	4
s	11.53	18.88	19.99
CV	7.6	14.8	27.9
CL	133.1-169.7	97.9-157.9	39.8-103.4
		P. mokattamensis	
$\bar{X}$	164.2	137.7	137.5
$s_{\bar{X}}$	7.22	7.78	-
N	4	4	2
s	14.4	15.56	-
CV	8.8	11.3	-
CL	141.2-187.2	112.9-162.5	-

Table 6.--Spatial and temporal distributions of *Pycnodus mokattamensis* (Pm) and *P. variabilis* (Pv), with minimum number of individuals (MNI)

Locality	Age	Pm	Pv	References
Mokattam, Egypt	Middle Eocene	1	7	Stromer, 1905; Priem, 1897
Gafsa, Tunisia	Early Eocene	1	0	Priem, 1903; this report
Rilassa, Algeria	Eocene	1	0	Savorin, 1915
Tocquevelle, Algeria	Eocene	2	1	Savorin, 1915; this report
Bord-Redir, Algeria	Eocene	1	0	Savorin, 1915; this report
Kouif, Algeria	Eocene	1	0	Arambourg, 1952; this report
Adabion, Togo(?)	Early Paleocene	0	3	Stromer, 1910; this report
Sokoto, Nigeria	Early(?) Paleocene	0	1	White, 1934
Gada, Nigeria	Early Paleocene	0	1	White, 1934
Wurno, Nigeria	Early Paleocene	0	2	White, 1934; this report
Landana (12c), Zaire	Paleocene	0	1	Dartevelle and Casier, 1949,
Landana (1), Zaire	Paleocene	0	1	1943; this report
	MNI:	7	17	

variabilis. As mentioned above, Dartevelle and Casier's species is a synonym of Stromer's P. variabilis.

The 12 pycnodont specimens from Jabal Umm Himar represent Pycnodus. Ten of these specimens are elliptical (or relatively wide) crushing teeth similar to Pycnodus and distinct from oval, circular, and hemispherical (or relatively narrow) crushing teeth of Palaeobalistum. The two remaining Umm Himar specimens are "incisors", which probably represent Pycnodus because of size and association with species of that genus.

In rocks of Early Tertiary age in Africa, there are three known species of Pycnodus: P. mokattamensis Priem, 1897, P. variabilis Stromer, 1905, and P. "cf. praecursor" Cappetta, 1972. In rocks deposited during the same time period in Arabia, which was then part of northeastern Africa, there also are three species of Pycnodus. However, the three species at Jabal Umm Himar are not the same three as those at localities in West Africa and North Africa.

PALEOCENE PYCNODONT FISHES FROM JABAL UMM HIMAR

Pycnodus sp. Agassiz, 1833-1843 (extremely large species)

A small splenial fragment collected from locality 1 in 1974 by D. L. Schmidt, USGS, has one crushing tooth from the inner dental row and parts of the alveoli for two adjacent, alternating teeth from the middle row (fig. 3A). This specimen contains the largest individual pycnodont tooth known from the Tertiary of Africa; it is 13.6 mm long and 34.7 mm wide. Its length and width exceed the 95 percent confidence intervals for Pycnodus mokattamensis (table 3, fig. 4), hitherto the largest pycnodont from the Tertiary of Africa. Its relative width (255.1) exceeds the confidence intervals for both P. mokattamensis and variabilis (table 4). Its great size and fairly high relative width indicate that the tooth is from the inner splenial row. Inner splenial teeth are always the largest and have the highest relative width of tooth types in either jaw of African Tertiary pycnodonts (tables 1-5). Madden and others(1979/1980, p. 15-17, table 3) identified this specimen as "...Pycnodus? sp..."

An isolated, inner-row crushing tooth from locality 43 is very similar in morphology (fig. 3B) and nearly identical in size (table 7, fig. 4) to the tooth in the splenial fragment from locality 1. The two specimens obviously represent the same species. The tooth from locality 43 is 13.1 mm long and 33.8 mm wide and has a relative width of 258.0. The striking similarities between these variables and those of the tooth

in the splenial fragment from locality 1 indicate that the locality 43 tooth is from the inner splenial row.

An isolated crushing tooth (fig. 3C) from locality 60 is 9.4 mm long and 26.4 mm wide and has a relative width of 280.9 (table 7). The extremely high relative width indicates that this specimen is an inner splenial tooth (tables 4-5, 7). Its length is within the 95 percent intervals for that character in Pycnodus mokattamensis, but its width exceeds the intervals for that species (table 3).

An isolated crushing tooth (fig. 3D) from locality 59 is 10.2 mm long and 20.0 mm wide and has a relative width of 196.1. This tooth is considered to be from the middle splenial row for several reasons. First, its width and relative width are significantly less than those variables for the three inner teeth described. z score statistical tests based on width and relative width show that the probabilities that this tooth was sampled from populations similar or identical to those for the three inner teeth are 6 chances out of 1,000 and less than 3 chances out of 100,000, respectively (table 7). Second, the tooth fits nearly perfectly into one of the partial alveoli for middle teeth of the specimen from locality 1 (fig. 3E). Length and width of the middle tooth are significantly greater than those characters in Pycnodus mokattamensis; z scores show that the probabilities that length and width were sampled from populations similar or identical for those of the North African Eocene Pycnodus are nearly 1 chance out of 100 (length) and less than 3 chances out of 100,000 (width). Relative width is within the confidence intervals for that character in P. variabilis but exceeds that for P. mokattamensis (table 4).

An isolated "incisor" tooth (fig. 3F) from locality 37E is extremely large, possibly the largest front tooth on record. It is 4.6 mm long, 9.6 mm wide, and 8.1 mm high, and its relative width is 208.7. Its great size suggests that this "incisor" probably represents the same species as the four crushing teeth just described. The tooth is considerably larger than the two worn "incisors" of a Pycnodus species from the middle Eocene of Mokattam, Egypt, described and figured by Stromer (1905, p. 186, pl. 16, figs. 31-32); one of these teeth, both of which probably represent P. variabilis, is reported to be 3.1 mm long and 2.3 mm high.

Pycnodus sp. Agassiz, 1833-1843 (medium-sized species)

An isolated, splenial crushing tooth (fig. 5A) from locality 37E represents a second species of Pycnodus from Jabal Umm Himar. The specimen is 4.4 mm long and 12.8 mm wide. These characters are less than the 95 percent confidence

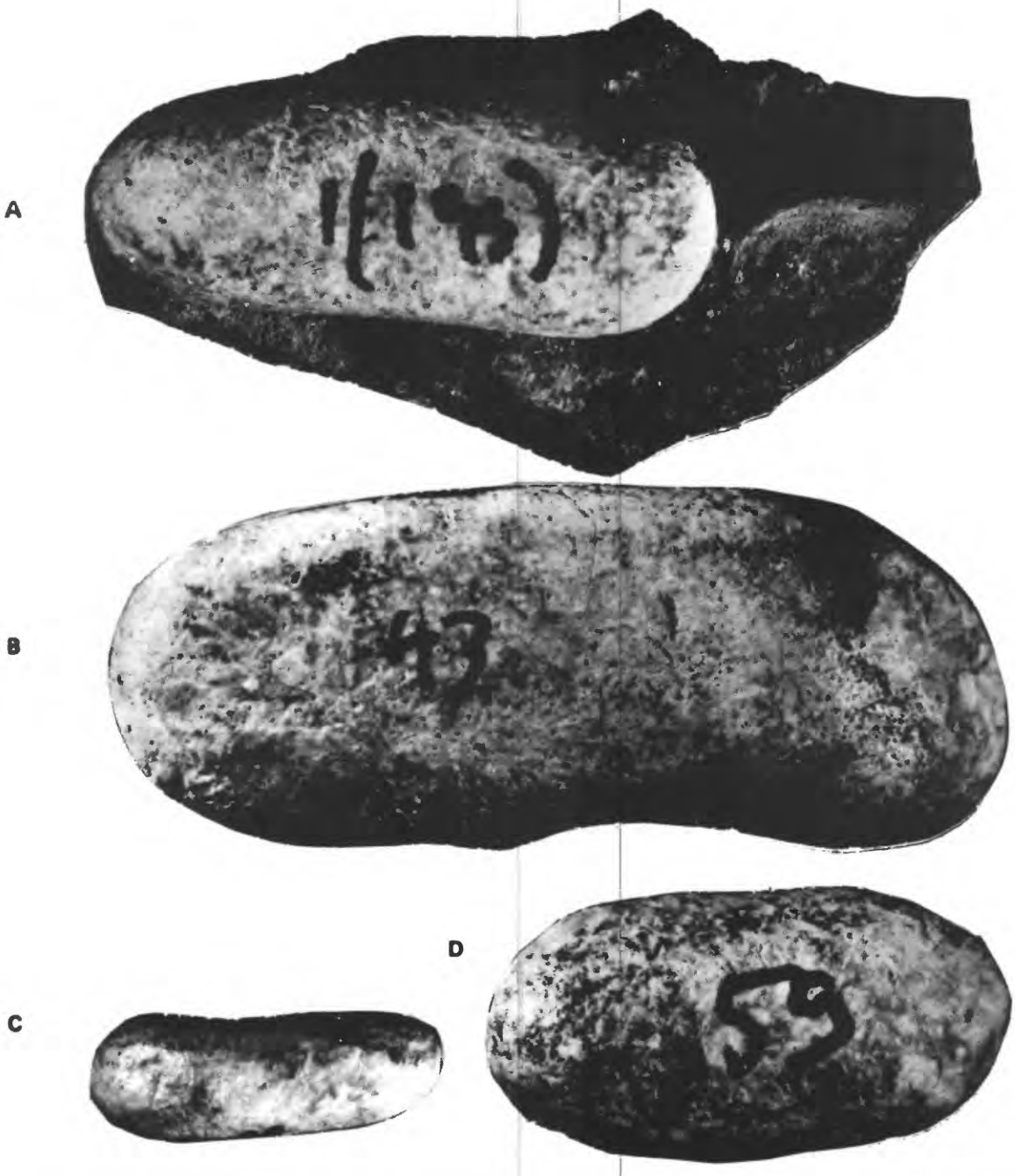

Figure 3.--Photographs showing specimens of Pycnodus sp. (extremely large species), collected in the Jabal Umm Himar area. Sample localities shown on figure 2.

A. Splenial fragment of extremely large Pycnodus sp. from locality 1, with crushing tooth from inner dental row and parts of alveoli for two adjacent, alternating teeth from middle row, crown view; width of tooth 34.7 mm.

B. Splenial inner row, crushing tooth of extremely large Pycnodus sp. from locality 43, crown view; width 33.8 mm.

C. Splenial inner row, crushing tooth of extremely large Pycnodus sp. from locality 60, crown view; width 26.4 mm.

D. Splenial middle row, crushing tooth of extremely large Pycnodus sp. from locality 59, crown view; width 20.0 mm.

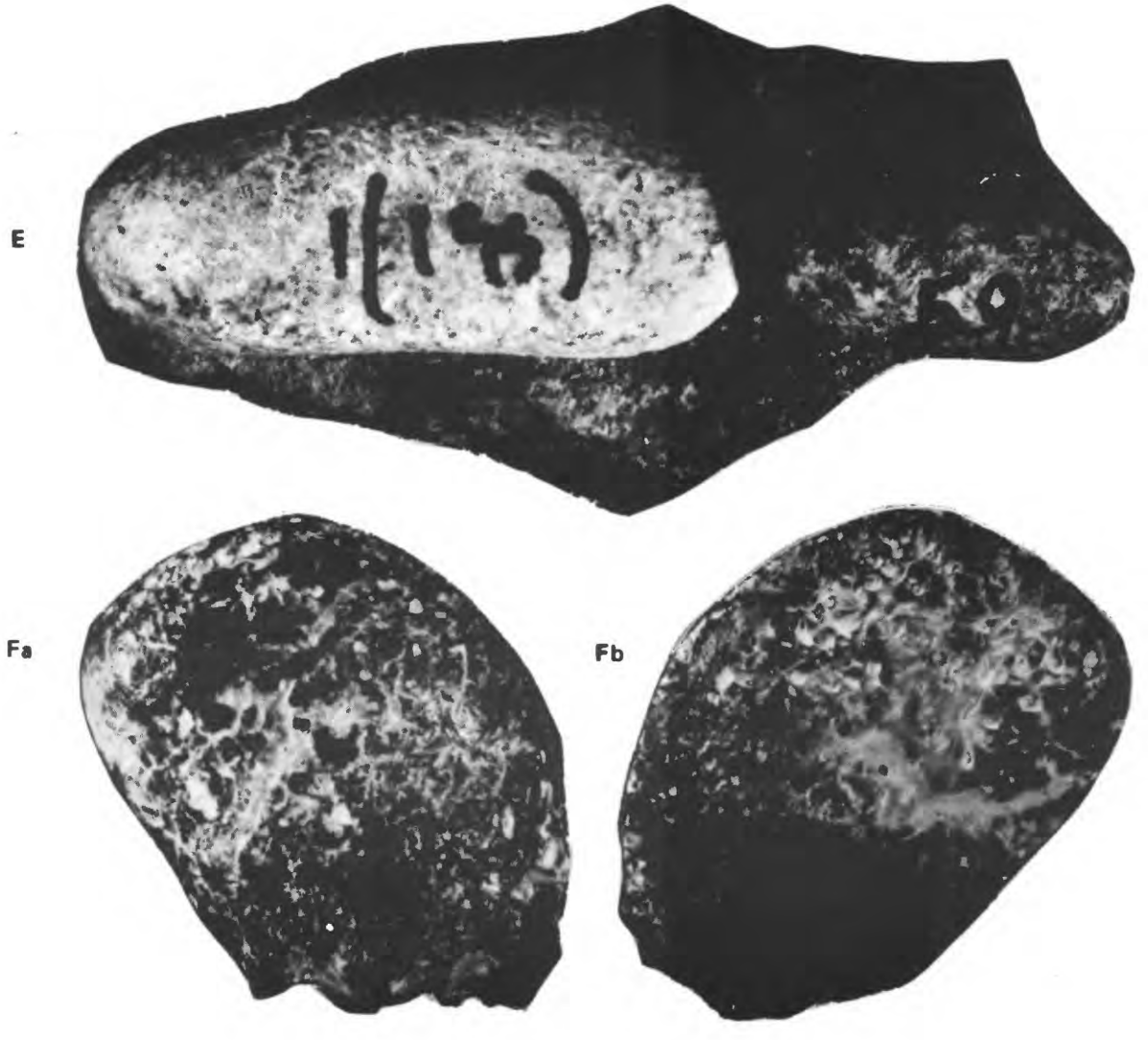

Figure 3.--Photographs showing specimens of Pycnodus sp. (extremely large species), collected in the Jabal Umm Himar area. Sample localities shown on figure 2--Continued

E. Nearly perfect fit of extremely large Pycnodus sp. tooth from locality 59 into one of partial alveoli for middle teeth in splenial fragment from locality 1, crown view; width of tooth from locality 1, 34.7 mm.

F. "Incisor" of extremely large Pycnodus sp. from locality 37E: a, anterior view; b, posterior view; width 9.6 mm.

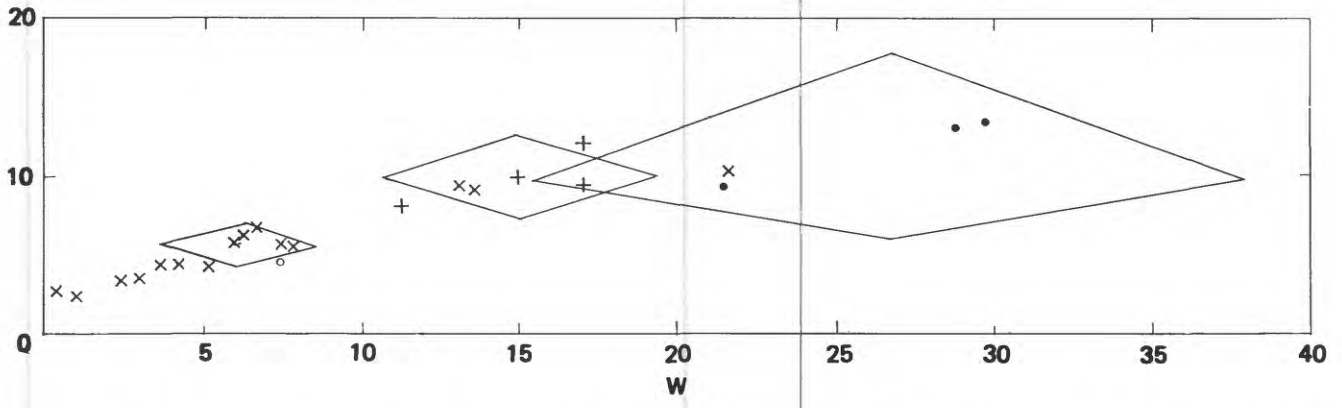

Figure 4.--Bivariate plot of length (L) and width (W) of crushing teeth in African Early Tertiary Pycnodus mokattamensis (+) and P. variabilis (x) and in Arabian Paleocene extremely large Pycnodus sp. (•) and medium-sized Pycnodus sp. (o), with 95 percent confidence intervals for first three species.

Table 7.--Individual observations and sample statistics for length and width of inner and middle splenial teeth in extremely large Pycnodus sp. from Jabal Umm Himar
[Leaders indicate no data available. Abbreviations defined in text. Sample localities on figure 2]

Sample locality	Inner		Middle		Relative width	
	L	W	L	W	Inner	Middle
1	13.6	34.7	-	-	255.1	-
43	13.1	33.8	-	-	258.0	-
60	9.4	26.4	-	-	280.9	-
59	-	-	10.2	20.1	-	196.1
$\bar{X}$	12.0	31.6	10.2	20.1	264.7	196.1
$s_{\bar{X}}$	1.32	2.63	1	1	8.17	-
N	3	3	-	-	3	1
s	2.29	4.55	-	-	14.13	-
CV	19.1	14.4	-	-	5.3	-
CL	6.3-17.7	20.3-42.9	-	-	229.5-299.9	
Alpha		0.05/2				0.05/2
z		-2.53				-4.85
P		0.006				0.00003

Table 8.--Individual observations and sample statistics for length, width, and relative width of crushing teeth in small Pycnodus sp. from Jabal Umm Himar
[Leaders indicate data not available; I, incomplete. Other abbreviations defined in text]

Sample locality	Splenial		Unknown		Splenial	Unknown
	L	W	L	W	Relative width	
2	3.15	5.75	-	-	182.5	-
33	2.85	5.70	-	-	200.0	-
37	-	-	3.55	4.55	-	128.2
$\bar{X}$	3.0	5.72	3.55	4.55	191.2	128.2
$s_{\bar{X}}$	0.15	0.025	-	-	8.77	-
N	2	2	1	1	2	1
s	0.21	.035	-	-	12.37	-
CL	1.1-4.9	5.40-6.04	-	-	79.8-302.6	-
1	2.35	I	-	-	-	-

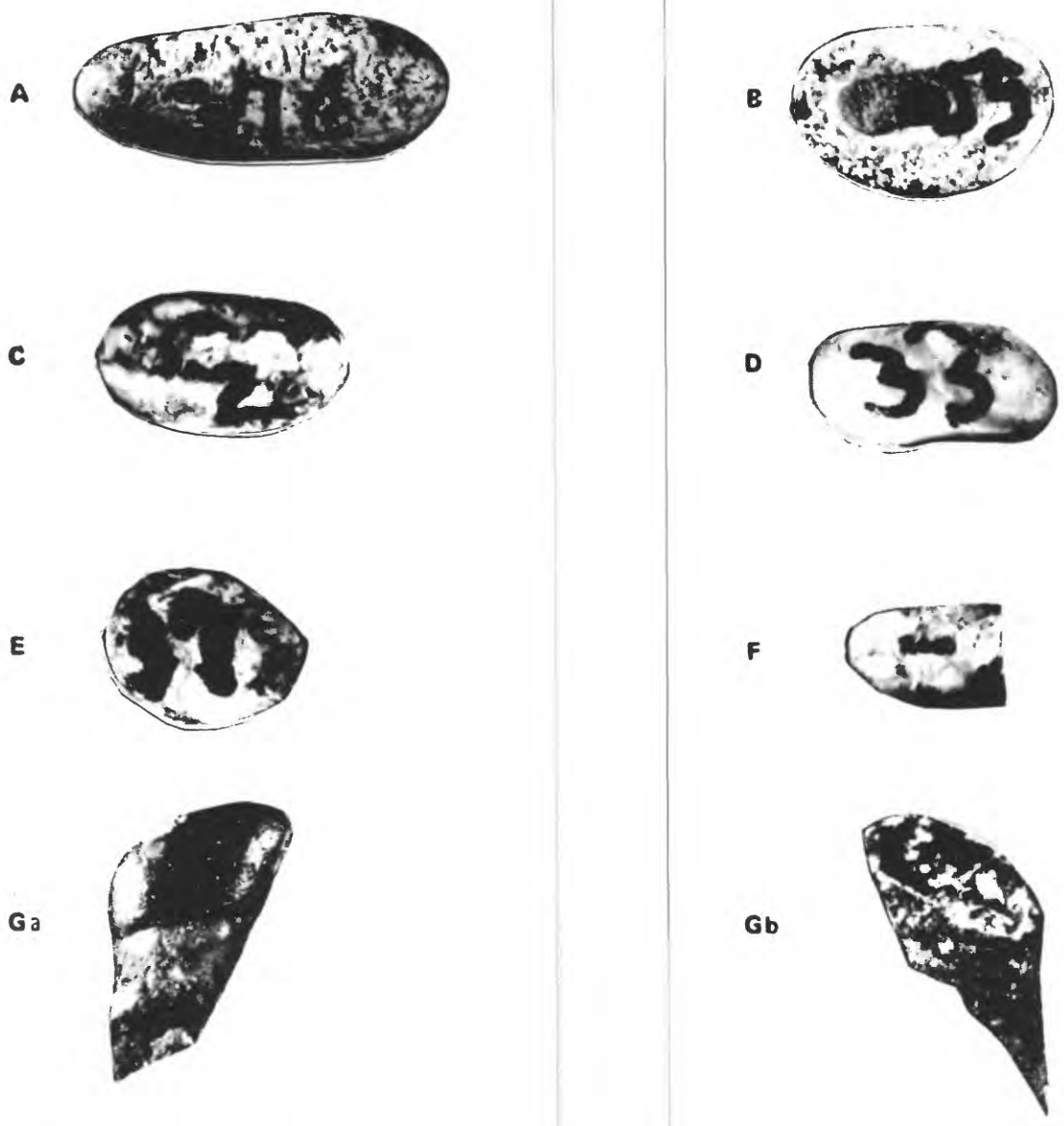

Figure 5.--Photographs showing specimens of Pycnodus sp. (medium-sized and small species), collected in the Jabal Umm Himar area. Sample localities shown on figure 2.

A. Splenial inner row, crushing tooth of medium-sized Pycnodus sp. from locality 37E, crown view; width 12.8 mm.
B. Worn, crushing tooth of medium-sized Pycnodus sp. from locality 59, crown view; width 8.9 mm.
C. Crushing tooth of small Pycnodus sp. from locality 2, crown view; width 5.75 mm.
D. Crushing tooth of small Pycnodus sp. from locality 33, crown view; width 5.70 mm.
E. Crushing tooth of small Pycnodus sp. from locality 37, crown view; width 4.55 mm.
F. Incomplete, crushing tooth of small Pycnodus sp. from locality 1, crown view; length 2.35 mm.
G. "Incisor" of small Pycnodus sp. from locality 2: a, anterior view; b, posterior view; width 3.40 mm.

intervals for the extremely large Pycnodus from the Umm Himar localities (table 7, fig. 4), and the specimen's extremely high relative width (290.9) indicates that it is from the inner splenial row (tables 4-5, 7). The dental size of the species represented by the present specimen is probably approximately that of P. variabilis, and both its length and width are within the 95 percent confidence intervals for that medium-sized African species (table 1). Judging from those two variables, the teeth of the medium-sized Pycnodus from Jabal Umm Himar are about 40 percent as large as those of the extremely large Pycnodus (table 7).

A worn crushing tooth (fig. 5B) from locality 59 appears to represent the same species as the inner splenial tooth from locality 37E. The specimen is 5.8 mm long and 8.9 mm wide and has a relative width of 153.4. The third variable indicates that the tooth is not from the inner splenial row and probably not from the middle splenial row. Its relative width is less than the confidence intervals for inner splenial row teeth in the extremely large Pycnodus, which encompass the value (290.9) for the inner splenial tooth of the medium-sized Pycnodus (table 7). Its relative width appears to be too low for the tooth to be from the middle splenial row; a tooth from that row would probably have a relative width similar to that of the one middle splenial row tooth (196.1; table 7) known for the extremely large Pycnodus from Jabal Umm Himar. The present specimen is either an outer splenial row tooth or a vomerine tooth, and it is too small to be a tooth of the extremely large Pycnodus. Outer splenial teeth in African Tertiary species of Pycnodus generally are about the same size as middle splenial teeth (tables 1, 3), and vomerine teeth in those species are either about the same size as their splenial counterparts or smaller than them (tables 2, 1, and 3).

Pycnodus sp. Agassiz, 1844-1843 (small species)

Four crushing teeth and an "incisor" collected from four localities represent a third, smaller species of Pycnodus at Jabal Umm Himar. The widest crushing tooth (fig. 5C) is from locality 2. It is 3.15 mm long and 5.75 mm wide and has a relative width of 182.5 (table 8). The next widest crushing tooth (fig. 5D) is from locality 33. This specimen is 2.85 mm long and 5.70 mm wide and has a relative width of 200 (table 8). Average relative width (table 8) suggests that these two teeth are from the splenial rows (tables 4-5), although which row is not determinable. However, judging from their very similar sizes and relative widths, the two teeth are almost certainly from the same dental row (table 8). A third crushing tooth (locality 37; fig. 5E) is considerably narrower than the first two teeth. It is 3.55 mm long and 4.55 mm wide and has a relative width of 128.2 (table 8).

Table 9.--Spatial distributions of extremely large (A), medium-sized (B), and small (C) species of Pycnodus from Jabal Umm Himar, with minimum number of individuals (MNI)

[Leaders indicate no specimen found. Localities shown on figure 2]

Sample locality	A	B	C
1	1	-	1
2	-	-	1-2
33	-	-	1
37	-	-	1
37E	1	1	-
43	1	-	-
59	1	1	-
60	1	-	-
MNI:	5	2	4-5

Its dental position is not determinable. The fourth crushing tooth (locality 1; fig. 5F) is shorter than the first two crushing teeth, but its length (2.35 mm) is within the 95 percent confidence limits for those teeth (table 8). It is probably from the same dental row as the first two crushing teeth. Its width cannot be measured because the tooth is incomplete. An "incisor" (fig. 5G) from locality 2 is structurally similar to but considerably smaller than the probable "incisor" of the extremely large Pycnodus from Umm Himar (fig. 3F). It is only 1.75 mm long, 3.40 mm wide, and 2.90 mm high. It is only 55 percent as long as one of the two "incisors" from Mokattam, Egypt, described and figured by Stromer (1905).

Table 9 summarizes the distribution of pycnodonts from Jabal Umm Himar by species size and locality number.

DISCUSSION

Three species of Pycnodus have been identified from the Paleocene fauna collected near Jabal Umm Himar, Saudi Arabia, an area that was contiguous with Africa during the Early Tertiary. One species is extremely large. Its inner and medial splenial teeth are roughly 60 percent and 100 percent wider, respectively, and its medial splenial teeth roughly 50 percent longer than those in early and middle Eocene P. mokattamensis, the largest species known for the Early Tertiary of Africa. This Pycnodus may well represent European early Eocene P. bowerbanki Egerton, 1877. Length, width, and relative width of inner and middle splenial crushing teeth in the holotype of the European species are 10.8 mm, 26.1 mm, and 241.7 (inner) and 8.0 mm, 17.0 mm, and 212.5 (middle), respectively (measured from type figure; Egerton, 1877, pl. iii, fig. 2). Variables for the inner teeth are within the 95 percent confidence limits for the extremely large Pycnodus from Umm Himar, and those for the middle teeth are also very similar (table 7). Savorin (1915, p. 377) provisionally identified P. bowerbanki from the Eocene of Tocqueville, Algeria. However, I hesitate even to provisionally identify the Arabian Pycnodus as Egerton's species because neither its entire upper dentition nor its outer splenial teeth has been sampled. Moreover, P. bowerbanki is unknown from Africa. The material Savorin provisionally identified as that species represents P. mokattamensis.

The second species from Jabal Umm Himar is a medium-sized Pycnodus and was identified at only two of eight sample localities. Its teeth are similar in size to P. variabilis and are only about 40 percent as large as the first (extremely large) Umm Himar species. The third species from Umm

Himar is a small Pycnodus. Although the position of its crushing teeth cannot be determined, this species clearly is distinct from the two other Pycnodontiformes from Jabal Umm Himar.

DATA STORAGE

No base data files, Mineral Occurrence Documentation Systems (MODS) entries, or Rock Analysis Storage System (RASS) entries were prepared for this report.

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